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ABSTRACT

The traditional K-3 social studies curriculum has focused on food, clothing, shelter, communication, transportation, and other cultural universals. Very little information exists about children's prior knowledge and thinking about these topics. This study was designed to provide such information with respect to the topic of transportation, and in the process to assess claims that primary students do not need instruction in the topic because they learn what they need to know about it through everyday living. Individual interviews were conducted with 96 K-3 students, stratified according to grade level, achievement level, and gender. Students were asked about transportation as a universal human need and the functions it fills. Overall they were asked to talk extensively about many and diverse aspects of transportation. Although inability to respond to the question was a frequent problem, the answers generated by the students who were able to respond tended to be accurate and relatively free from misconceptions. Their responses, however, were restricted to the micro-level of the activities of individuals and families, without addressing the macro-level of society in general or the world at large. Sophistication of responses showed statistically significant relationships with grade level. Findings suggest that instruction in cultural universals belongs in the primary grades social studies curriculum, but curricular treatments should be more powerful than those typically offered by textbook series. Contains 39 references. Appended are the transportation interview and a table of distributions and correlation coefficients showing relationships of coding categories to grade level, achievement level, and gender. (Author/BT)

PRIMARY-GRADE STUDENTS' KNOWLEDGE AND THINKING ABOUT TRANSPORTATION AS A CULTURAL UNIVERSAL

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Abstract

The traditional K-3 social studies curriculum has focused on food, clothing, shelter, communication, transportation, and other cultural universals. Very little information exists about children's prior knowledge and thinking (including misconceptions) about these topics. The study was designed to provide such information with respect to the topic of transportation, and in the process to assess claims that primary-grade students do not need instruction in the topic because they learn what they need to know about it through everyday living. Individual interviews were conducted with 96 K-3 students, stratified according to grade level, achievement level, and gender. The students were asked about transportation as a universal human need and the functions that it fulfills for us; the evolution of transportation over time and the impact of inventions; the tendency for settlements to be built along transportation routes; the ways in which improvements in transportation have "made the world smaller;" the fundamental importance of the wheel as a basic invention; how modern life differs from earlier times as a function of improvements in transportation; the effects of building a highway through a rural community; the effects of improvements in transportation on farming and consumer access to farm products; special forms of transportation found mostly in cities (trains, buses, taxis) and what is involved in using them; how automobiles work; problems that exist in places where most people drive cars or trucks; the nature and uses of maps; the need for traffic control mechanisms; and considerations involved in traveling across national borders. Although inability to respond to the question was a frequent problem, the answers generated by the students who were able to respond tended to be accurate as far as they went and relatively free of misconceptions. However, the students were able to provide only limited answers to many of the questions because their responses were restricted to the micro-level of the activities of individuals or families, without addressing the macro-level of society in general or the world at large. Sophistication of responses typically showed statistically significant relationships with grade level, but only minor and scattered relationships with achievement level and gender. Findings are discussed with emphasis on their implications for early elementary social studies.

Anthropologists and other social scientists often refer to cultural universals (sometimes called "social universals" or "basic categories of human social experience") as useful dimensions for understanding a given society or making comparisons across societies (Banks, 1990; Brown, 1991). Cultural universals are domains of human experience that have existed in all cultures, past and present. They include activities related to meeting the basic needs of food, clothing, and shelter, as well as family structures, government, communication, transportation, money or other forms of economic exchange, religion, occupations, recreation, and perhaps others as well. The term implies that activities relating to each cultural universal can be identified in all societies, but not that these activities necessarily have the same form or meaning in each society. On the contrary, it recognizes variations among societies (as well as among individuals within societies) in orientation toward or handling of common life events associated with each cultural universal (e.g., family structures are universal, but different cultures and individuals within cultures have different notions of what constitutes a family).

Cultural universals have special importance for early elementary social studies because much of the basic content taught in the primary grades focuses on them. The traditional reasoning has been that teaching students about how their own and other societies have addressed the human purposes associated with cultural universals is an effective way to establish an initial, predisciplinary knowledge base in social studies, preparing the way for the more discipline-based courses of the middle and upper grades. Two major reasons are cited commonly by supporters of the argument that organizing early social studies around cultural universals provides a sound basis for developing fundamental understandings about the human condition. First, human activities relating to cultural universals account for a considerable proportion of everyday living and are the focus of much of human social organization and communal activity, so instructional units on cultural universals provide many natural starting points for developing initial social understandings. Until they understand the motivations and cause-and-effect explanations that underlie these activities, children do not understand much of what is happening around them all the time. As they develop such understanding, previously mysterious behavior of their parents and other people significant in their lives becomes comprehensible to them, and they become equipped with intellectual tools that will enable them to begin to develop efficacy in these domains themselves.

Second, children from all social backgrounds begin accumulating direct personal experiences with most cultural universals right from birth, and they can draw on these experiences as they construct understandings of social education concepts and principles in the early grades. If cultural universals are taught with appropriate focus on powerful ideas and their potential life applications, all students should be able to construct basic sets of connected understandings about how our social system works (with respect to each cultural universal), how and why it got to be that way over time, how and why related practices vary across locations and cultures, and what all of this might mean for personal, social, and civic decision making.

Not everyone agrees with this rationale, or even with the notion of social studies as a pre- or pandisciplinary school subject organized primarily as preparation for citizenship. Some people advocate basing school curricula directly on the academic disciplines. They would offer separate courses in history, geography, and the social sciences, simplified as needed but designed primarily to pursue disciplinary goals rather than citizenship education goals. With particular

reference to the primary grades, Egan (1988), Ravitch (1987) and others have advocated replacing topical teaching about cultural universals with a heavy focus on chronological history and related children's literature (not only historical fiction but myths and folk tales). We agree that K-3 students can and should learn certain aspects of history, but we also believe that these students need a balanced and integrated social education curriculum that includes sufficient attention to powerful ideas drawn from geography and the various social sciences, subsumed within citizenship education purposes and goals. Furthermore, we see little social education value in replacing reality-based social studies with myths and folklore likely to create misconceptions, especially during the primary years when children are struggling to determine what is real (vs. false/fictional) and enduring (vs. transitory/accidental) in their physical and social worlds.

Some of those who are opposed to a focus on cultural universals in early social studies have asserted, without presenting evidence, that there is no need to teach this content. Ravitch (1987) dismissed it as "tot sociology," arguing that it holds little interest or value for students, partly because they already know it from everyday experience. Larkins, Hawkins, and Gilmore (1987) also suggested that primary-grade students already know most of this content, so there is no need to teach it in school. The authors of this report have disputed these arguments, suggesting that the knowledge about cultural universals that children develop through everyday experience tends to be tacit rather than well-articulated. Furthermore, much of it is confined to knowledge about how things are without accompanying understandings about how and why they got to be that way, how and why they vary across cultures, or the mechanisms through which they accomplish human purposes (Brophy & Alleman, 1996).

Recent developments in research on teaching suggest the need for data that speak to this issue. Increasingly, theory and research have been emphasizing the importance of teaching school subjects for understanding, appreciation, and life application, using methods that connect with students' prior experience and engage them in actively constructing new knowledge and correcting existing misconceptions. In mathematics and science, rich literatures have developed describing what children typically know (or think they know) about the content taught at their grade levels. This information informs the design of curriculum and instruction that both builds on students' existing valid knowledge and addresses their misconceptions.

There is potential for applying similar methods in social studies if more is learned about children's ideas about topics commonly taught at school. So far, little such information exists about topics addressed in K-3 social studies. Child development researchers have concentrated on cognitive structures and strategies that children acquire through general life experiences rather than on their developing understanding of knowledge domains learned primarily at school. Research in the Piagetian tradition has focused on mathematical and scientific knowledge, although there have been some studies of stages in the development of economic, political, and social knowledge (Berti & Bombi, 1988; Furnham & Stacey, 1991; Furth, 1980; Moore, Lare, & Wagner, 1985).

Nor have scholars concerned with curriculum and instruction developed much of this kind of information. There have been occasional surveys of knowledge about particular social studies topics (Guzzetta, 1969; Ravitch & Finn, 1987; U.S. Office of Education, 1995a, b).

However, these have concentrated mostly on isolated facts such as names, places, or definitions, with reporting of findings limited to percentages of students able to answer each item correctly. To be more useful to educators, the research needs to emphasize questions that probe children's understanding of connected networks of knowledge and analyses that focus on qualitative aspects of their thinking about the topic, including identification of commonly held misconceptions.

Significant progress has been made in studying children's developing knowledge of politics and government. For example, children are much more aware of the administrative than the legislative or judicial aspects of government and they tend to view presidents as godlike figures notable for their power to get things done and their benevolence or caring about the needs of each individual citizen (Connell, 1971; Greenstein, 1969; Hess & Torney, 1967; Moore, Lare, & Wagner, 1985; Stevens, 1982). Research on economics knowledge has begun to uncover stages in children's development of understanding of, as well as common misconceptions in their ideas about, such topics as the functions of banks and the operations of retail stores (Berti & Bombi, 1988; Berti & Monaci, 1998; Byrnes, 1996; Jahoda, 1984; Schug, 1991).

Several teams of investigators have studied children's historical learning (Barton & Levstik, 1996; Brophy & VanSledright, 1997; McKeown & Beck, 1994). This work has demonstrated, for example, that much of the historical knowledge of fifth graders is organized in narrative form, so that it tends to feature stories focused around a few hero figures rather than less personalized causal analyses of historical trends. The students' narratives also tend to compress time and space by depicting face-to-face interactions between people whose life spans did not overlap (e.g., Columbus and the Pilgrims).

Very little information is available concerning children's knowledge and misconceptions relating to the cultural universals emphasized in K-3 social studies curricula. As a first step toward developing such information, we interviewed middle-class students late in the spring of second grade on various aspects of the topic of shelter (before and after they experienced an instructional unit on the topic). Shelter is not only a cultural universal but a basic need, and all of the students had had experience with it throughout their lives. Thus, if Ravitch and others had been correct in their assertion that children develop clear knowledge about such topics through everyday experience, we should have seen such knowledge demonstrated by middle-class children who were nearing the upper end of the primary-grade range. Instead, we found that the students' prior knowledge about topics relating to shelter was limited and spotty, tacit rather than well-articulated, comprised of loose collections of observations rather than well-integrated knowledge networks that included awareness of connections and understanding of cause-effect relationships, and often distorted by inaccurate assumptions or outright misconceptions (Brophy & Alleman, 1997).

These findings motivated us to launch a series of studies on developments across Grades K-3 in students' knowledge and thinking about cultural universals. Our intention is to generate findings that will have immediate value to social educators interested in developing more powerful curriculum and instruction for the early grades and teaching in ways that connect with students' prior knowledge. We also expect the findings to be of interest to scholars who study developments in children's general cognition or domain-specific knowledge.

All of these studies involve interviewing large samples of students stratified according to grade level (K-3), prior achievement level (high, average, low), and gender (boys, girls). In addition, the first two studies (on shelter and clothing) involved stratifying students according to the socioeconomic status (SES) of the populations served by their respective schools (upper middle-class suburban, middle-class suburban, lower middle-class urban). Interview protocols feature questions designed to elicit extended statements of students' thinking about the topic. Responses are coded for the presence of commonly mentioned ideas or response elements, and scores derived from these codes are subjected to quantitative statistical analyses. In addition, unusual responses or elaborations of common responses that go beyond the basic ideas represented by the coding categories are listed and discussed in the reports. Analyses focus on general levels of knowledge and trends observed across grade levels, but with attention to how these trends interact with prior achievement level and gender. Findings are discussed with emphasis on their potential implications for curriculum and instruction in primary-grade social studies and on what they suggest about more general developments in children's social knowledge and thinking. Complete technical reports concerning students' knowledge and thinking about shelter (Brophy & Alleman, 1999b) and clothing (Brophy & Alleman, 1999a) already are available, and reports about food and about communication have been submitted to ERIC. Subsequent reports will feature government and family living.

Children's Knowledge and Thinking About Transportation

Despite longstanding emphasis on transportation in early social studies, practically no information exists about developments in children's knowledge and thinking about the topic. A dissertation study done in 1947 tested fourth- through ninth-graders' understanding of a variety of social concepts (Bates, 1947). Transportation was one of the concepts that the author found to be familiar to students at all of the grade levels included. That is, most of even the fourth graders were able to define the term correctly. Unfortunately, this study did not include the K-3 grade range.

The only other studies located that touched even indirectly on topics addressed in our interview were studies of children's understanding of public ownership that included questions about the ownership of buses (Cram, Ng, & Jahveri, 1996; Furth, 1980). These studies indicated that children in kindergarten either do not know who owns buses or identify as owners people who are in close spatial contact with them (for example, passengers). As they progress through the elementary grades, they later identify the owner as the person who uses or controls the use of the object (e.g., the bus driver), then the person who controls the use of the object by others (e.g., the bus driver's boss), and only later the local government or transit authority that provides transportation to the area. These studies focused on ownership of buses rather than on the buses themselves, so they did not provide information about children's understanding of this particular form of transportation.

Our Transportation Interviews

We developed an interview protocol designed to elicit students' thinking about what we consider to be key ideas that ought to be emphasized in an elementary social studies curriculum that treats transportation as a cultural universal. The content base for the interview was

synthesized from three general sources: (1) social studies education textbooks and other sources that identified key ideas about transportation that are rooted in the social science disciplines; (2) information about transportation typically included in elementary social studies textbook series or in children's tradebooks on the topic; and (3) our own ideas about the key features of elementary social studies units that focus on cultural universals and are designed to teach the material for understanding, appreciation, and life application (Brophy & Alleman, 1996). We believe that the most basic and important ideas for children to learn about transportation include: understanding its status as a universal human need and the functions that it fulfills for us; the evolution of transportation over time and the impact of inventions; the tendency for settlements to be built along transportation routes; the ways in which improvements in transportation have "made the world smaller;" the fundamental importance of the wheel as a basic invention; how modern life differs from earlier times as a function of improvements in transportation; effects of building a highway through a rural community; effects of improvements in transportation on farming and consumer access to farm products; special forms of transportation found mostly in cities (trains, buses, taxis) and what is involved in using these forms of public transportation; how automobiles work; problems that exist in places where most people drive cars or trucks; the nature and uses of maps; the need for traffic control mechanisms; and considerations involved in traveling across national borders.

After identifying and sequencing the content base to be addressed, we developed and revised initial drafts of the interview protocol. These drafts featured primarily open-ended questions, typically followed by planned probes, designed to elicit extended statements of students' knowledge and thinking about the topic. Probes were designed to reveal whether students understood and could explain the concepts or relationships addressed by the initial questions (and if not, what alternative concepts or relationships they might have constructed).

The "funnel" interview technique was used, in which initial broad questions encourage students to make extended statements about a topic, attending to whatever aspects of the topic they select for focus on their own initiative, and explaining themselves in their own words. Probing then begins with follow-up questions asking (if necessary) for clarification or elaboration of what students have said in their initial statements. Finally, more specific questions are asked (if necessary) to call students' attention to aspects of the topic that they did not address spontaneously. This approach maximizes the degree to which students' responses reflect their own unique stances toward and construction of knowledge about the topic, and it minimizes the cueing of specific responses through suggestive questions. Yet, it also ensures that all of the students address certain key aspects of the topic (either because they do so spontaneously in responding to initial broad questions or because they are asked more specific questions later).

Successive drafts of the interview were piloted with students who were not involved in the later study. This pilot work led to revisions designed to make sure that all questions were clear, to specify probing and follow-up questions more completely, and to eliminate questions that were too easy or difficult to be useful. This process eventually yielded the final version of the interview shown in Appendix 1.

Sample

Our first two studies (on shelter and clothing) involved interviews with 216 students, 54 in each of Grades K-3, stratified within each grade by the socioeconomic status (SES) level of the community, the students' prior achievement levels, and the students' gender. The SES variation was introduced by conducting one-third of the interviews in an upper-middle class suburban community, one-third in a middle/working-class suburb, and one-third in lower-middle/working class neighborhoods of a small city. Together, these samples subsumed the middle three-fourths or so of the SES range in the general population.

The patterns of findings that appeared in the first two studies led us to discontinue further systematic sampling across the SES range, because the observed SES differences in these studies were relatively small and not especially interesting or informative. Students from higher SES backgrounds tended to have more, or more accurate, knowledge than students from lower SES backgrounds, but the same general developmental patterns were observed in each group. We did not find theoretically or practically interesting group contrasts (e.g., contrasts suggesting the existence of qualitatively different developmental paths or constructions of knowledge that were unique to particular SES groups). Consequently, we concluded that in our future work it would be more efficient to concentrate initial studies at the middle of the SES distribution (by interviewing in the same middle/working class suburb for which the middle SES samples in the first two studies were drawn). Possible group differences would then be addressed in follow-up studies. For example, we followed up the shelter study by interviewing students who lived in Manhattan, a highrise, high-density residence area that contrasts with the lowrise, low-density communities of the Michigan students interviewed in the initial study. Also, given that our food interview included several questions on farming and the origins of food, we followed up the initial food study with interviews of students from farm families.

The students interviewed for this study attended the public schools of a middle/working class bedroom suburb of a small city (population about 160,000). The community is average or slightly above average on most socioeconomic and educational indices. During the years when these interviews were conducted, the community's high school graduation rate was 83% and the percentages of its fourth graders who achieved "satisfactory" scores on the state's achievement tests were 49% percent for reading and 65% for mathematics.

Reflecting their school populations, the majority of the students we interviewed were white. We did not consider race or ethnicity in identifying students for the sample, except for the stipulation that all interviewees must have spent all or at least most of their childhood in the United States. Recent immigrants or students who had spent most of their preschool years in other countries were not included, because an assumption underlying the work was that what the students knew about transportation (other than what they had been taught at school) had been learned in the process of growing from infancy in the contemporary United States (particularly through home and neighborhood experiences and exposure to television and other media).

Interviewees were selected from among students whose parents gave us permission to do so. Most parents who returned our forms did give such permission, although a significant minority of parents never returned the forms despite repeated requests. Once the potential

interviewees in a given classroom were identified, they were listed alphabetically by gender and the teacher was asked to characterize them, within gender groups, as being within the upper third, the middle third, or the lower third in general academic achievement. When we had access to more students in a given cell (e.g., high achieving male first graders) than we needed, the students to be interviewed were selected randomly from within the eligible group. When additional students were needed to fill out certain cells, we expanded sample recruitment to a nearby school in the same district that served a very similar student population.

Collection and Preparation of Data

Students were interviewed individually. The interviews typically lasted about 30 minutes and were conducted in small offices or other locations within their schools but outside of their classrooms. To facilitate rapport with students and make sure that their responses were preserved verbatim, the interviews were tape recorded, using a microphone that could be placed unobtrusively on the table and did not require either the interviewer or the student to handle it or speak directly into it. Interviewers were instructed to establish good rapport with the student before beginning and then to conduct the interview in a relaxed and conversational style rather than a more formal or test-like style.

The tape recorded interviews were transcribed by one person and then listened to by a second person who identified omissions and inaccuracies in the transcripts. Data for statistical analyses were then developed by coding the corrected transcripts.

Coding the Transcripts

We did not attempt to force students' responses into predetermined coding categories. Instead, we allowed the categories to arise from the data, using what have been called analytic induction methods for developing grounded theory (Bogdan & Biklen, 1982; Glaser & Strauss, 1979; Patton, 1990). Coding schemes were developed by reading responses to each question and identifying common ideas (embodied in similar statements) that represented alternative ways to respond to the question. Responses then were coded for the presence or absence of mention of these common ideas. Multiple codes were assigned if the student mentioned more than one of the ideas. In addition to categories encompassing common ideas, each coding scheme contained an "other" category for flagging rare or unique responses.

After initial versions of the coding schemes were developed and refined, reliability was established between two coders who coded one-fourth of the transcripts (stratified according to grade level, achievement level, and gender). Upon completion of this coding, the two sets of codes were compared and inter-coder agreement percentages were computed. Most coding schemes initially met our criterion of 60% exact agreement across coders. When coding schemes failed to meet the inter-coder agreement criterion, the coders analyzed the problem and made adjustments in the coding schemes, then coded the one-fourth sample of responses again. All of the revised coding schemes met the inter-coder agreement criterion at this point. Across the 30 coding schemes used, exact agreement percentages ranged from 70% to 100%, averaging 81%.

Once the coding schemes had met the reliability criterion and been revised as needed (to incorporate minor alterations or elaborations suggested by insights developed while coding to establish reliability), the two coders used them to code all 96 interviews. Upon completion of their independent coding, they compared their codes and negotiated agreement on all discrepancies. They also developed a running list of the rare and unique responses that had been coded into the "other" categories, as well as any unusual elaborations of common ideas that seemed worth preserving for possible inclusion in this report. Thus, the report encompasses not only the commonly observed response variations that were amenable to statistical analysis, but also the rare or unique responses and any elaborations on common responses that seemed worth including because they appeared to have theoretical or practical significance.

Once coding was completed, the codes were converted into scores that became the bases for statistical analyses. In most cases the codes were used as is. However, some commonly occurring responses that originally were coded in an "other" category were broken out to create new scores, and some categories that were coded too infrequently to serve as a basis for useful statistical analyses were folded into related categories or simply omitted from such analyses. For example, Question 19 asked why people in cities use buses or subways instead of cars. The original coding distinguished the statement that these people do not have cars from the more specific statement that these people do not have the money to buy a car for themselves. Preliminary analyses indicated that this distinction was not worth maintaining, so these two codes were combined into a single one indicating that the people use buses or subways because they do not own cars.

Data Analysis, Interpretation, and Presentation

Scores derived from the codes were subjected to statistical analyses designed to reveal trends in the sample as a whole as well as contrasts across subgroups of students who differed in grade level, achievement level, or gender. These analyses included frequency distributions and means reflecting the degree to which various ideas were expressed across the sample as a whole and within its stratified subgroups, correlation coefficients indicating the direction and degree of relationship among the variables, and Chi-Square analyses indicating when subgroup differences were large enough to reach statistical significance.

Initial inspection of the results of these analyses indicated that (1) the response patterns to most questions featured statistically significant and often quite dramatic grade level differences showing increases in level and accuracy of knowledge across the K-3 range, (2) the achievement level differences, and (especially) the gender differences were much smaller and less likely to reach statistical significance, and (3) most of the achievement level differences that did appear were in the expected direction and thus not especially interesting or informative (that is, students who were higher in prior achievement level tended to have more, or more accurate, knowledge than students who were lower in prior achievement level, but the same general developmental patterns were observed in each group).

Given the uniformity of this pattern (with very minor exceptions that are noted when the relevant data are discussed), we decided to organize the presentation of findings in this report as follows. First, findings from related clusters of questions are presented together. For each

question cluster, data presentation begins with discussion of descriptive statistics and the progressions in students' knowledge across Grades K-3, illustrated with excerpts from eight students' interview responses. We then present the findings on achievement level and gender differences. Except where the data indicate otherwise, we treat these group differences as relatively minor variations on the main themes established by the grade level differences.

Next, we turn to the correlational data, reporting noteworthy patterns that appeared in the relationships between the response categories under discussion and the categories used to code responses to other questions in the interview. These relationship patterns help us to interpret the meanings and implications of the various response categories, both in their own right and relative to one another. They are especially helpful when the grade level, achievement level, or gender differences found for a response category seem counterintuitive (if the meaning of the category is taken at face value). Sometimes, the correlational patterns indicate that the responses coded into a category had different meanings or implications (e.g., were either more or less sophisticated) than the category descriptor seemed to imply.

After presenting these quantitative data, we turn to a more holistic analysis of what the findings suggest about developments in children's knowledge and misconceptions about transportation as they progress through Grades K-3. Along with the data shown in the tables, these analyses include consideration of the rare and unique responses and unusual elaborations of common responses that were recorded and analyzed for potential significance. Taken together, these findings are discussed with reference to previous findings (where available), the understandings we have developed about growth and change in children's knowledge and misconceptions relating to transportation, and the potential implications of these understandings for curriculum and instruction in elementary social studies.

Why People Need Transportation

The first two questions assessed students' understanding that transportation is a universal human need:

1. Today we're going to talk about transportation. What does transportation mean? (If student does not know, explain that transportation refers to how people travel or get from one place to another.)

2. Is transportation just something that people enjoy, or do they need it? . . . What are some times when they need it?

The first question was asked to determine how the students would define transportation in their own words, assuming that they were able to do so. If they were not, or if their definition was incorrect, overly specific, or otherwise problematic, the interviewer defined the term for them before proceeding to Question 2.

Responses to the first question indicated that more than half (57) of the 96 students were unable to define transportation. The remaining students produced responses in one or more of the following categories: defining transportation as changing location or going from one place to

another (30); stating that the term refers to a vehicle, conveyance, or means of getting around (12); naming a specific type of vehicle or mode of transportation (10); or saying that transportation means moving someone or something (9). Thus, although only a minority of the students were able to respond to this question, what these students said tended to be accurate. No incorrect definition appeared frequently enough to constitute its own coding category.

Responses to Question 2 indicated that a heavy majority (86) of the students understood that people need transportation, at least some of the time. However, seven students were unable to respond to this question and three said that people enjoy transportation but do not actually need it. The latter response is defensible, although most observers would say that transportation is a basic need these days, at least for people living in developed countries. When asked to explain why people might need transportation, 61 of the students mentioned local travel (to stores, schools, jobs, hospitals or doctors' offices, friends' homes, etc.), 23 mentioned long-distance travel (e.g., to Florida or California on vacation or to visit relatives), and seven talked about how people sometimes might need to take a taxi or get a ride from a friend if they did not own a car or if their car was being repaired.

The following examples are representative of responses to the first two questions. They are segments drawn from verbatim transcripts of the interviews, although they have been edited to eliminate extraneous material (mostly final probes that failed to elicit any additional response). Here and throughout the rest of the report, the examples are drawn from the transcripts of interviews of eight average achieving students, one boy and one girl from each of Grades K-3.

Kindergarten

Jered

1. I don't really know.

2. To get from one place to another. (Yeah, do they need it or do they just enjoy it?) Need it. (What are some times when they need it?) Hmm . . . I forget right now.

Kate

1. I don't know.

2. They need it. (What are some times when they need it?) To go shopping and get some food and get some clothes.

First Grade

Chris

1. I don't know.

2. They need it. (What are some times when they need it?) When they go to school and when they go to stores and stuff and exercise.

Lauren

1. I don't know.

2. They need it. (When are some times when they need it?) Like when they need to go on vacation and they need to go to the store or something. And they help people get to the hospital and they help people when their car is out of gas; they can go to the gas station with another car.

Second Grade

Mark

1. Like if you go somewhere, like if you ride a train or a car or bus or plane.

2. They need it. (When are some times when they need it?) If they're like poor and they don't have enough money for a car and they just take a cab or a bus or a train. (What are some times when you have to be able to travel or have transportation?) Like if you're going on a business trip.

Emily

1. I don't know.

2. Like if they're lost and can't find their way home or to school, then their moms can go to the school and help them find their way, and help them walk to their classroom if they forgot. (Do people go from one place to another because they want to or because they need to?) Because they need to. (When are some times when they might need to?) Like if somebody might have lice, then they might go to the emergency room or go to the nurse.

Third Grade

Dale

1. Like to get somewhere.

2. They need it to get places—get to different places. (What are some times when people need transportation?) Usually need it to get places, and usually after work if you're a teenager, some people go on buses in the morning to get to school, and after school they go on the bus to get home. That's when you need it, or it's for work too.

Chelsea

1. Like a bus . . . if you have to go on a bus, then that's transportation because you go from one place to another. So is a car.

2. They need it. (What are some times when they need it?) When . . . like if their cousin was in the hospital.

Grade Level Differences

Descriptive statistics and information from the Chi-square analyses of scores derived from the coding of Question 1-3 (and all of the other questions in the interview) are given in Table 1. The numbers in the columns for the total sample (N = 96), the four grade level groups (N = 24), the three achievement level groups (N = 32), and the two gender groups (N = 48) are simple frequency scores indicating the numbers of students in the sample as a whole and within each grade level, achievement level, or gender group who were coded for mentioning the idea represented by the response category. Sets of scores are underlined if the analyses described below identified statistically significant relationships between the frequency of use of a response category and the students' grade level, achievement level, or gender.

The score distributions were subjected to Chi-square analyses to determine whether the differences observed reached the .05 level of statistical significance. Two forms of Chi-square analysis were used. The first, used with all of the distributions, was a conventional Chi-square analysis that assesses the probability of obtaining the observed group totals if it is assumed that the variable appears with the same frequency in each group within the population as a whole (in other words, if it is assumed that there are no group differences). This Chi-square test does not take into account that the groups might be ordered on a dimension (e.g., grade level or achievement level). Consequently, a statistically significant result simply indicates that the variance in the group totals exceeds that which might be expected to occur because of chance variations in sample characteristics.

A related analysis, the Mantel-Haenszel Chi-square test, was used to assess the statistical significance of trends observed in the grade level and achievement level distributions. These two distributions involved a progressive ordering of their categories (from kindergarten through third grade, and from low through average to high achievement level). The Mantel-Haenszel statistic takes into account such progressive ordering and tests for directional trends (i.e., tendencies for the scores to either rise or drop as one moves up the grade or achievement levels). Statistically significant Mantel-Haenszel Chi-squares do not imply that the difference between each successive grade level or achievement level score is statistically significant, or even necessarily consistent with the overall trend. However, they do indicate that a statistically significant rising or dropping trend was detected across the four grade levels or the three achievement levels.

In compiling the data for Table 1, we first examined the grade level and achievement level comparisons for the significance of the Mantel-Haenszel Chi-square. If this Chi-square was significant at or below the .05 level, we underlined the group totals and recorded the phi coefficient (comparable to a conventional correlation coefficient) to indicate the direction and level of strength of the relationship between grade level (or achievement level) and the frequencies of coding of the response category in question. If the Mantel-Haenszel Chi-square

did not reach the .05 level of statistical significance, we examined the findings for the conventional Chi-square. Usually this Chi-square also failed to reach significance, in which case we did not underline the group totals or record a phi coefficient in the table. In a few instances, the Mantel-Haenszel Chi-square was not statistically significant but the conventional Chi-square was. This indicated that there was statistically significant variation across the groups being compared, but this variation did not take the form of a systematically rising or dropping trend that paralleled the grade level or achievement level progression. Where these unexpected nonlinear group differences appeared, we underlined the group totals and placed the letters "NL" (standing for nonlinear) in the phi coefficient column. In summary, for the grade level and achievement level analyses, we (1) underlined the set of group totals and included the phi coefficient when the analyses indicated a significant directional trend, (2) underlined the set of group totals and entered "NL" when the analyses indicated significant nonlinear variance, and (3) did not underline the set of group totals and did not enter either a phi coefficient or the letters "NL" when neither of the Chi-square analyses yielded a significant result.

The Mantel-Haenszel Chi-square test was not appropriate for assessing the statistical significance of gender differences, because the two gender groups (boys, girls) are not ordered on a continuum. Consequently, the conventional Chi-square test was used for this purpose. When this test indicated a statistically significant difference between the two gender groups, the gender totals were underlined and the phi coefficient was entered to indicate the direction and strength of the relationship (negative phi coefficients indicate that the boys were coded significantly more frequently in the category than the girls; positive phi coefficients indicate that the girls were coded significantly more frequently than the boys). When the Chi-square test failed to indicate statistical significance, the gender totals were left without underlining and no phi coefficient was entered. To simplify the table, decimal points were omitted from all of the phi coefficients recorded.

The first line in Table 1 indicates that only one kindergartener and one first grader were able to offer a definition of transportation, whereas 15 second graders and 22 third graders were able to do so. This is one of the strongest relationships with grade level that we have encountered for any response category in any of our interview studies. Apparently, these children typically learn the meaning of the term late in first grade or early in second grade.

Significant relationships with grade level also were seen for the remaining categories. The second and third graders were more likely than the kindergarteners and first graders to define transportation as changing location or as moving someone or something, as well as to name a mode of transportation or say that the term refers to a means of getting around. In summary, almost all of the kindergarten and first grade students were unable to define transportation, almost all of the third graders were able to do so, and the second graders were in a transition state, with 15 of them able to do so but nine unable to do so.

Other significant relationships with grade level indicated that the older students were more likely than the younger ones to say that people need transportation and to identify everyday local transportation needs in elaborating their responses. There were no significant relationships with grade level for responses focusing on long distance travel or on transportation needs of people who do not have a car available to them.

Achievement Level and Gender Differences

The categories for the responses to the first two questions showed one significant relationship with achievement level and two with gender. The achievement level difference occurred because most of the seven students who said that people need transportation when they do not have a car were higher achievers.

The gender differences indicated that eight boys but only one girl defined transportation as moving someone or something, whereas nine girls but only three boys defined it as a conveyance or means of getting around. These gender differences are more stylistic than substantive. Inspection of the set of the categories as a whole does not suggest that either gender was more successful than the other in answering these first two questions.

Relationships Among Response Categories

Although our interests lay more in group differences in response patterns, we also correlated scores for the different response categories, within and across question clusters, to see if any noteworthy relationships emerged. Most of the significant correlations were not especially interesting because they fit into one of three expected patterns. First, many were logically necessary negative correlations between mutually exclusive category alternatives within the same cluster (e.g., there was a negative correlation between failure to define communication and the category used to code the definitions that were given by the students who were able to do so). Second, some were logically necessary positive correlations that reflected part-whole relationships. For example, Question 3 asked how people got around back in the pioneer days, and some students mentioned wagons or covered wagons, others referred to oxen or horse-drawn vehicles, and still others referred to carriages or buggies. All three of these response categories were correlated with a broader category for mentioning animal-pulled vehicles (because all of the students who were coded in any of the first three categories also were coded in the larger category).

Third, there was a general tendency toward correlation within and across clusters in the length and quality of the students' responses (i.e., certain students were more likely than others to be unable to respond or to respond poorly to our questions; certain students were more likely than others to consistently make lengthy and complex responses; and certain students were better informed than others and thus more likely to consistently make sophisticated responses). Given that these three types of relationships were expected to appear and that the explanations for them are well understood, we will not describe them in this report unless there is some special reason to do so.

In addition to these expected relationships, however, the correlational analyses sometimes identified statistically significant relationships between response categories that would not necessarily have been predicted and that indicated interesting connections among students' ideas. Most of these interesting relationships involved categories that reflect qualitative differences in the ways that students approached the questions, as opposed to categories that reflect differences in the amount or accuracy of their knowledge.

There were several sets of noteworthy intercorrelations involving categories for responses to the first two questions. Students who answered Question 1 by naming a vehicle or mode of transportation were more likely than other students to also define transportation as changing location or going from one place to another, to name animals (oxen, horses) or vehicles (carts, wagons, carriages, buggies) used for transportation in the cave days, to know that apples are available in Michigan in the winter because they are imported from other states or countries, to think that the cost of using a taxi is determined by the time required for the trip, and to say that one problem that exists in places where most people drive cars or trucks is that it is difficult for people or animals to cross busy streets.

Students who answered Question 1 by indicating that transportation involves moving someone or something were more likely than other students to say that if we did not have cars we wouldn't be able to get around as quickly, to say that a town would be noisier if a highway was built through it, and to define a taxi as a car that you pay to use.

Students who defined transportation as changing location or going from one place to another were more likely than other students to name a vehicle or mode of transportation in responding to Question 1, as well as to identify animals (oxen, horses) or vehicles (carts, wagons, carriages, buggies) used to get around back in the cave days. This set of responses came from students who made more sophisticated responses to Questions 1 and 3.

Defining transportation as changing location or going from one place to another also correlated positively with quite a number of additional responses on subsequent questions: saying that changes in transportation have made the world smaller because there are now more buildings, vehicles, train tracks, etc. taking up space; the world is smaller now because we can travel more quickly and are connected to more people and places than before; we cross mountains more easily now because we can drive over them on roads or take trains through them in tunnels; the wheel was an important invention because people can go faster on wheeled vehicles and because you can move things more easily without having to drag them; we couldn't get around as quickly if we only had horses and wagons today; if we had trains but no cars, we would walk more and travel would involve more crowding and hassle; building a highway through a town would bring more noise and more dangerous traffic and accidents, but some positive changes as well; access to trucks helped farmers because they could use the trucks to take things to markets; apples are available in Michigan in the winter because they are imported from other states or countries; cars and buses are kinds of transportation found in big cities but not in other places; people use buses or subways instead of cars because they go faster than cars; a taxi is a yellow or checkered car that has a sign on top or a number on the back; a car runs because the engine makes the wheels turn; and one problem that exists in places where most people drive cars or trucks is pollution (air pollution, dust, gas/oil spills).

Students who defined transportation as a means of getting around, a conveyance, or a vehicle were more likely than other students to say that people need transportation when they have to travel for long distances and that building a highway through a small town would make the town noisier and create more dangerous traffic and accidents.

Except for the cluster of intercorrelations involving responses to Questions 1 and 3, these intercorrelations involving responses to Question 1 were not expected and are not easily interpretable, with one major exception. The exception involved responses that correlated because they were part of a "maturity set" of response categories that were coded more frequently for older and better informed students. Across the interview as a whole, this maturity set included the following responses: defining transportation as changing location or going from one place to another; defining transportation as a means of getting around, a conveyance, or a vehicle; naming a vehicle or mode of transportation in responding to Question 1; stating that people got around in the pioneer days using wagons or covered wagons; naming trains, planes, or ships in addition to common road vehicles in talking about forms of transportation that we use now that people didn't have long ago; saying that airplanes allowed people to go to farther-away places than they could go previously; saying that changes in transportation have made the world smaller because we now have less space due to more vehicles, train tracks, airports, etc. (note that this response is part of the maturity set even though it misses the metaphor and takes the phrase "made the world smaller" literally); stating that people built cities along railroad lines so they could get to the train more easily; saying that modern vehicles make it easier to cross mountains than it used to be; stating that the wheel was an important invention because people can go faster on wheeled vehicles and do not have to drag things; stating that if we had only horses and wagons today, it would be harder for us to get around; stating that if we had trains but no cars, travel would be inconvenient because trains don't usually stop at the exact place you wish to reach and also trains involve crowding and hassle; understanding that a highway built through a small town would bring noise and more dangerous traffic and accidents, but also recognizing that it would bring benefits as well; recognizing that trucks allowed farmers to get things to market much more easily; knowing that apples are imported from other states or countries during the winter; identifying buses, trains, taxis, and airplanes as forms of transportation found in big cities but not other places; defining a taxi as a car that you pay to use and understanding that people use taxis because they do not have cars; understanding that the cost of a taxi ride is determined by its length; knowing some of the details of how cars work; identifying pollution as a problem in places where there are many cars; defining a map as something that represents a geographical area or tells you where places are; and recognizing that we need stop lights to control traffic and prevent accidents. Throughout the rest of the report, when we indicate that a response category was part of the maturity set of responses to the interview as a whole, we mean that it tended to correlate positively, and often significantly, with the coding categories just identified.

In contrast to the categories for responses to Question 1, none of the categories for responses to Question 2 showed noteworthy correlations with other response categories.

Rare and Unique Responses

The following responses to the first two questions involve interesting elaborations on the ideas represented by the coding categories or embody ideas that are not included in those categories. Many of these responses have been paraphrased to save space and focus on their key ideas, although occasionally rare or unique responses are quoted verbatim when it appeared worth doing so.

Question 1

Only three responses to the "What is transportation?" question yielded unusual responses: A kindergartener said "Listening to yourself on the music," another kindergartener said that transportation is talk (thinking of communication), and a first grader similarly said that transportation is talking ("You talk to others, they contact you and stuff"). Otherwise, the responses were well captured by the coding categories.

Question 2

The following were rare and unique responses concerning why we need transportation.
Kindergarten: None

First grade: You need to walk to get exercise (two first graders made this response, apparently associating the word "need" in the question about why we need transportation to the notion that we need exercise); fly to the sun (apparently in a rocket ship) (associates the term transportation with space travel, perhaps due to Star Trek or other television programs).

Second grade: You need transportation in bad weather (2) or when you have to get somewhere fast (2); you use transportation on special occasions like holidays (apparently thinking of driving long distances to visit relatives).

Third grade: You need transportation when you are going a long way (2).

Discussion

Less than half of the students were able to respond to the first question asking for a definition of transportation, but a heavy majority of these students were able to respond correctly by defining transportation as moving or changing location and/or talking about the means (vehicles) involved. Two students confused the term "transportation" with the term "communication" and one thought that the term referred to travel in outer space, but otherwise the responses were free of misconceptions. Apparently, this is a term that most children learn relatively quickly and easily once they are exposed to it, which is not surprising given the concrete and easily observable nature of transportation.

Compared to their responses about food, clothing, and shelter, the students were less likely to say that transportation is a basic need. However, a heavy majority of the students did make this response.

The nine categories for responses to the first two questions yielded seven significant relationships with grade level, three with achievement level, and two with gender. The grade level differences were relatively dramatic, primarily because almost none of the kindergarteners and first graders but noteworthy majorities of the second graders and third graders were able to define transportation. Higher achievers gave somewhat more accurate definitions of transportation than lower achievers. Finally, the girls did somewhat better than the boys in defining transportation and identifying occasions when or reasons why people need it.

Transportation in the Past and Present

Question 3 assessed students' knowledge about transportation through three time periods: the cave days (prehistoric times), the pioneer days (early 18th century), and the present.

3A. Let's talk about transportation in the past. How did people get around way back in the days when people used to live in caves?

3B. How did people get around back during the pioneer days?

3C. What kinds of transportation do we use now that people long ago didn't have?

Question 3A concerned transportation in the cave days. Fifteen of the students were unable to respond to this question, five said that people rode in "Flintstone" vehicles featuring stone wheels, and another five mentioned cars or other modern vehicles. Thus, 15 students could not respond to the question and 10 others made responses that were grossly incorrect.

Most (66) of the rest of the students correctly said that people walked in the cave days. In addition or instead, 10 said that they rode animals (oxen, horses) and 10 said that they used carts, wagons, or other wheeled vehicles.

Question 3B asked about transportation in the pioneer days. Here, 30 students were unable to respond and another 8 mentioned cars, taxis, or other modern vehicles. The remaining responses were spread over several categories: wagons or covered wagons (24), walking (15), oxen or horses (15), boats or ships (14), and carriages or buggies (7). A total of 38 students mentioned travel by some form of animal-pulled vehicle.

Question 3C asked about modern forms of transportation that people didn't have long ago. Only five students were unable to respond to this question or mentioned only walking, riding animals, or riding bicycles. The remaining students almost all mentioned engine-powered vehicles. Among this heavy majority, 59 students only mentioned common road vehicles (cars, trucks, buses, motorcycles), and 32 others mentioned trains, planes, or ships in addition to common road vehicles.

In general, most substantive responses to Question 3 were accurate, although significant minorities of students were unable to respond to Questions 3A and 3B and some of the responses to these questions revealed misconceptions (Flintstone vehicles seen in cartoons, the notion that modern vehicles were used in the cave days or the pioneer days). The following examples from average-achieving boys and girls are representative of responses from students across the four grade levels.

Kindergarten

Jered

3A. Walk.

3B. Walk.

3C. Cars.

Kate

3A. They would just make caves. (Yeah, but how did they get from one place to another?) They took a bus or a bike or walked or drove.

3B. They took a car.

3C. Well, they walked. (What didn't they have?) Cars.

First Grade

Chris

3A. They walked.

3B. They had these cattle thingys and they still have them and they have a horse, two horses taking them somewhere.

3C. Cars. (Anything else?) Nothing I can think of.

Lauren

3A. They walked. (Is there anything else they could use for transportation back then?) They could run.

3B. They rided horses and they had a little buggy that hooked onto the horse's head and they walked sometimes and sometimes they'd run.

3C. We have cars and we have vans, we have trucks, and we have wagons and we have bike, and we have a . . . I don't know what else we have.

Second Grade

Mark

3A. They used to use horses.

3B. I don't know.

3C. Cars. Buses. Trains. Airplanes.

Emily

3A. Walk or ride on horses.

3B. Riding in a carriage.

3C. Cars.

Third Grade

Dale

3A. They used rocks for tires and more rocks for the sides and wood for the other stuff. What do you call those—like on the Flintstones? (I don't know.) I know they used to have cars that would run on their feet. (OK, but that's from the Flintstones—the cartoon. Do you think the real people in the olden days back when they lived in caves looked like that or do you think it's a story?) It's a story but the cars might be real and true—the cars, I think are true, and maybe the dinosaurs.

3B. What were the pioneers' wagons called? I gotta figure out what they were called—buggies or something.

3C. Cars, trucks, buses, skidoos, boats.

Chelsea

3A. They used to walk and sometimes they could make stuff with wheels but sometimes something has to pull it.

3B. With ships.

3C. Cars, trains, airplanes.

Grade Level Differences

Significant relationships with grade level were seen for categories of responses to Questions 3A, 3B, and 3C. Younger students were more likely than older students to be unable to respond to these three questions and they also were more likely to say that the pioneers used cars or other modern vehicles. Older students were more likely than younger students to provide the more sophisticated responses: to say that cave people rode animals or used simple wheeled vehicles, to say that the pioneers traveled in boats or ships or used animal-pulled vehicles, and to mention trains, planes, or ships in addition to common road vehicles in talking about modern forms of transportation.

One nonlinear relationship with grade level appeared: First graders and especially second graders were more likely than kindergarteners or third graders to talk about the use of oxen or

horses in the pioneer days. This may have been because more students in first and second grade read books about the pioneers during language arts or studied the pioneers during social studies. This is an educated guess based on our general impressions about curriculum content in the early grades in these schools, however, not a firm explanation based on specific information collected on curriculum content in these particular classrooms.

Nonlinear patterns such as these are usually not expected, and we typically have no explanation for them. Sometimes interpretations are suggested by intercorrelations between the response category involved and other categories for coding responses to the interview as a whole, by previously reported findings on nonlinear patterns in children's cognitive development, or by what we know about the content of the school curriculum across the K-3 range. Usually, however, nonlinear findings are left uninterpreted. Rather than continue to repeat our explanations for why this is the case (the patterns were unexpected, their reliabilities are unknown, and nothing in the correlational analyses or the extant research literature suggests clear interpretations), throughout the rest of this report we will simply describe nonlinear patterns without commenting on them (except in a few instances like this one, where we do have an interpretation to suggest).

Achievement Level and Gender Differences

The 16 response categories for the three parts to Question 3 yielded 12 significant relationships with grade level but only two with achievement level and three with gender. The achievement level differences indicated that more low achievers said that people got around by walking back in the pioneer days. Also, three low achievers but no high achievers were among the five students who failed to mention motor vehicles in talking about modern transportation. Both of these are low-level responses to Questions 3B and 3C (respectively), so it is not surprising that they were made more frequently by lower achievers than by higher achievers.

Two of the gender differences were in categories for responses to Question 3A, where nine girls but only one boy suggested that people used carts, wagons, carriages, or buggies in the cave days, whereas 38 boys but only 28 girls said that they walked. This difference favors the boys, because carriages and similar wheeled vehicles were not yet in use back in the cave days. Girls also made more mention of carriages or buggies in responding to Question 3B. Here, 7 of the girls but none of the boys suggested that carriages or buggies were used in the pioneer days. This time the tendency to mention carriages or buggies favored the girls, because these in fact were common means of conveyance in the pioneer days.

Relationships Among Response Categories

Students who suggested that cave people used either modern vehicles or "Flintstone" vehicles were more likely than other students to mention the use of modern vehicles in the pioneer days. Students who said that cave people rode oxen, horses, or other animals were more likely than other students to say that the pioneers used carriages or buggies. Students who said that the cave people used wheeled vehicles also were more likely than other students to say that the pioneers used carriages or buggies, as well as to say that the coming of the railroad allowed people to get to many more places, especially faraway places.

Students who said that the pioneers mostly or exclusively walked were more likely than other students to say that they welcomed the railroad because it allowed them to get places without having to walk. Students who mentioned trains, planes, or ships in addition to common road vehicles in talking about modern transportation were more likely than other students to mention planes in talking about transportation found in big cities but not other places. Otherwise, the noteworthy intercorrelations involving categories for responses to Question 3 were relationships between the more sophisticated responses to this question and the maturity set of responses to the interview as a whole.

Rare and Unique Responses

Question 3A: Transportation in the Cave Days

Kindergarten: Wheelbarrows.

First grade: They rode dinosaurs; they made a car and drove it; they invented cars and trains; bikes; baby strollers; boats and dinosaurs.

The following first grader is quoted for her good reasoning from limited information, including denial of the "Flintstone" theory: By walking. (Any other way?) If they had a bike, they'd use a bike. (Did they have bikes back when people lived in caves?) Only if someone invented one. (Do you think they were invented then?) I would say no. They would be made out of rock and you could barely lift it.

Second grade: The following second grader is quoted as an example of the Flintstone theory: They walked and they invented things they could use—little cars made out of rocks and stuff. They had rocks for wheels and sticks to make them roll inside, and you know where the pedals are? (Yes.) Well, there's nothing there and you make your feet go and once you get fast enough, it just stays going along. (That's interesting. How did you learn that?) From the Flintstones.

Third grade: They rode mammoths.

For the following third grader, the cartoon cars from the Flintstones were more real than the dinosaurs: They used rocks for tires and more rocks for the sides and wood for the other stuff. I know they used to have cars that would run on their feet, like on the Flintstones. (OK, but that's from a cartoon. Do you think the real people in the days back when they lived in caves did that, or do you think it's a story?) It's a story but the cars might be real and true—the cars, I think, are true, and maybe the dinosaurs.

3B: Transportation in the Pioneer Days

Kindergarten: They rode goats or something.

First grade: Bikes; bikes and airplanes.

Second grade: None.

Third grade: Bikes.

3C. Transportation Today

Kindergarten: Indy cars, monster trucks, jet skis; skateboards; limos; tractors, horse trailers.

First grade: Baby strollers; boats; scooters and roller blades.

Second grade: Ships; boats (2).

Third grade: Boats (3), sailboats and hot-air balloons; motor homes; skidoos; roller blades; go carts.

Discussion

Most students who were able to respond to the parts of Question 3 were generally accurate in what they had to say, although a few believed that the cave people actually used stone-wheeled "Flintstone" vehicles and some thought that the cave people and/or the pioneers used modern engine-powered vehicles. More than two-thirds of the students correctly said that the cave people mostly walked, although some thought that they rode animals or used animal-pulled carts or wagons.

Surprisingly, only 38 students mentioned animal-pulled vehicles in talking about transportation in the pioneer days, and more students were unable to respond to this question than to the question about transportation in the cave days. The younger students actually appeared to know more about the cave days than the pioneer days. Responses concerning contemporary transportation modes were almost all accurate, although there were noteworthy differences in the range of vehicles mentioned.

Older students generally had more, and more accurate, knowledge than younger students, but surprisingly this was not true of higher achievers relative to other students. Higher achievers did provide more accurate information about travel in the pioneer days, but they provided less accurate information about travel in the cave days. There was only one significant gender difference, part of a slight trend for boys to provide more information about travel in the pioneer days. A few students showed misconceptions induced by the Flintstones and other cartoon series and a surprisingly large percentage (almost a third) of them were unable to respond to the question about travel in the pioneer days, but otherwise most of what the students had to say was accurate or at least defensible in characterizing travel at the three time periods addressed.

Changes Brought by Innovations in Transportation

Questions 4-8 addressed the students' understanding of the ways that key innovations in transportation brought new opportunities into people's lives and "shrunk the world" by developing connections between formerly isolated places.

Question 4. For a long time, the Native Americans didn't have horses, but then they got horses. How did horses change their lives?

Question 5. For a long time, people had only horses and wagons to get around in, but then the railroad was built. What could people do after the railroad was built that they couldn't do before? . . . Why would they choose to do that?

Question 6. Later, highways were built. What could people do after highways were built that they couldn't do before?

Question 7. Then, airplanes were built. What could people do after airplanes were built that they couldn't do before?

Question 8. Some people say that all of these changes in transportation have "made the world smaller." What do they mean by that?

Question 4 produced a variety of responses. Twenty-two students were unable to respond to the question, but the remaining students suggested a number of ways in which horses changed the lives of the Native Americans: 18 said that now these people could ride or did not have to walk (without elaborating further), 26 said that they didn't have to expend as much energy or get as tired or footsore as they did formerly when they had to walk everywhere, 18 said that they could now get places more quickly, 21 said that they could now go farther or visit places that they could not reach previously, and 14 made perhaps the best response, indicating that riding on horses made fighting, hunting, and finding food easier.

Half of the students answered Question 5 by saying that the coming of the railroad made it possible for people to get to places more quickly, and 24 said that trains allowed them to get to more places or farther-away places. In addition, 20 students were unable to respond to the question, 13 said that trains made travel easier or more fun, 7 noted that trains allowed people to travel in comfort, shielded from the elements, and 11 gave "other" responses such as that trains were cheaper, could carry more people or things, allowed the traveler more space (compared to a stage coach, for example), and did not require stopping to let horses rest.

Concerning Question 6, 18 students were unable to respond and 27 said only that highways allowed people to drive cars, trucks, or other road vehicles. However, 25 students noted that this allowed people to get places faster, 18 that they could go to more faraway places and to places that trains did not go to directly, and 8 that highways allowed cleaner and safer travel because people were traveling in cars on smooth, paved roads rather than dusty or dirty ones. Finally, 7 students reacted to the term "high" within the word "highway:" They said that highways allowed people to travel up high instead of down lower because the roads were raised

above the surrounding land and often went over bridges that took them over other roads. A few students included the idea that highways include bridges over rivers and thus allow cars to cross rivers, apparently believing that trains are unable to do this.

Question 7 proved to be the easiest of this series for the students. Only seven of them were unable to respond to it. The most popular responses were that airplanes allowed people to get places faster (42), to go to farther-away places (28), or to go to different states or countries (22). Other responses included the ideas that airplane travel is more fun, easier, or more relaxing than other forms of travel (10), that the coming of air travel meant that people could now ride in airplanes (without further elaboration) (9), that airplanes can travel over water/oceans (9) and that airplanes are preferable to cars because they don't run out of gas, get flat tires, get stuck in traffic, have to stop at stoplights, etc.(8).

Young children tend to have difficulties with metaphor, and the notion that transportation has "made the world smaller' was no exception. When asked to explain the meaning of this statement, a majority (56) of the students were unable to respond, and another 30 took the statement literally and said that developments in transportation take up space (for the vehicles themselves, for buildings such as airports or train stations, for train tracks, etc.) and thus have resulted in some destruction of nature and reduction of available space for homes, parks, or other human purposes. Only eight students suggested that the term means that now we can travel more easily, get places faster, or are better connected with other people and places.

Taken together, the responses to these questions continue the trends established in responses to the first three questions. That is, although inability to respond was frequently a problem, what was said by the students who were able to respond was mostly accurate or at least defensible. Differences were more in the level of specificity of the response or the degree of focus around main ideas than in the general accuracy of the statements or the presence of misconceptions. Most students easily grasped the big idea that each successive innovation in transportation made it possible to travel farther, quicker, and easier than before. However, only a few students understood the connotations of the statement that improvements in transportation have "made the world smaller." Subsequent data indicated that the poor response to this question was not just a difficulty in dealing with metaphor. Most students easily grasped the advantages that transportation innovations brought to individual travelers but showed little awareness of the role of these innovations (along with innovations in communication) in transforming the world from a collection of isolated social systems into a single large and mostly well-connected network. This is but one facet of a larger set of findings from our interviews indicating that students are much more knowledgeable about micro-level events that occur within families or local neighborhoods than they are about macro-level events that affect the nation or the world at large. The following examples from average-achieving boys and girls are representative of the responses from the students across the four grade levels.

Kindergarten

Jered

4. I don't really know.

5. The train driver could go down the track to get somebody to another place. (They could do that, and why would they choose to do that?) Because if they didn't have a car, then they would have use to use a train. (Why would they use the train?) Because they could get someplace to the other.

6. They could drive. I can go on a highway because there's a highway to my grandma's and I go to my grandma's and the car helps us get to my grandma's.

7. Fly a plane. (Why would they choose to do that?) Because then they would be able to go quicker to a place way far away.

8. I don't know.

Kate

4. Well, they came to a city—the horses came to a place where people didn't have anything. (How did horses change their lives?) Well, they came to the Indian spot and found them. (What could they do with the horses that they couldn't do before?) They could ride on it.

5. They could go on it. (If they could go on it, what could they do that they couldn't do before?) They didn't have to walk.

6. They didn't have to walk anymore—they drive.

7. They could ride on them and you could ride on a horse if you had one.

8. It means that the world is not that huge anymore.

First Grade

Chris

4. They could ride faster and then they can transportate somewhere else.

5. Ride on the train. (And why would they want to do that?) Because the train's faster and sometimes you get where you want to go.

6. Drive cars. (And why would they choose to drive cars instead of taking the train? Or riding on horses or wagons?) I don't know—because it had air conditioning.

7. They could fly and they could just go straight where they wanted to go. (Well, why would they choose to take the plane?) Because they get drinks and stuff for you and you get to eat on the plane and you get to go straight and they have very warm air conditioning when you just click the button up there on the top of the thing.

8. I don't know.

Lauren

4. They could take them to other places without them walking and they could take them places that they like if they weren't riding a horse to go get food, they could. And the horses could run. That's all. (Well, you've said that the Native Americans could use horses so they didn't have to walk places. Why would they rather ride the horses than walk?) Well, I think it would be easier to go by horses. (And why do you think that?) Because sometimes they get tired of walking. (Are there any other reasons why people would rather ride horses than walk?) Because it's easier to get places. (Why is it easier to get places on a horse?) Because horses are faster than you.

5. They could ride the train. (Why do people choose to ride trains?) Because they could get people places and because they could take people to Chicago and wherever they needed to. (Why do you think people would want to ride trains instead of riding a horse and wagon?) Because trains are bigger and faster than a horse and wagon. (Can you think of anything else that the trains could do for people that horses and wagons couldn't do?) They could take people places and they could go anywhere they would like to.

6. Well, they could go faster and when the cars were built they could ride on it. And I think that big trucks can go on it. (OK, you said that cars on the highway would be faster than the transportation forms that people had before. Why could you go faster in a car on the highway?) Because you can go fast on the highway and you can get places faster on the highway.

7. Well, if they wanted to they could fly. And they could get places even faster. It would take a couple of days flying in an airplane. (What do you mean that it would take a couple of days for an airplane?) Because sometimes some airplanes are slow. They like want to go really slow to stop and look in the sky. (Anything else that airplanes could help people do that they couldn't do before they were invented?) They're going to give people places that they couldn't go in cars. Then they could take people other places that they need to go. (What are some places that people couldn't get to in a car?) It would take a pretty long time to get to Florida in a car and they could not go around the world. (Why couldn't they go around the world in a car?) Because it would take them like days and days and days and days and anyway, there's oceans in it going around the world. (Could you go around the world in an airplane?) You could go above people but I don't think you could go around the world in a plane, not outside, but I think you can go like around the world when you're like outside and you go other places in an airplane.

8. Well, like they invent a lot of stuff so the world is smaller. (OK. Did the world actually get smaller?) Well, I can't be sure because I'm not outside on the world right now, but when they build like houses and the grasses like are getting smaller because they put houses on the grass when they do that.

Second Grade

Mark

4. Before they could just like walk, and after they usually didn't want to walk because they were tired.

5. They couldn't go on the trains before it was built, and now they can go on trains, because they don't want to go on horses because horses weren't fast enough.

6. Cars. (Can you think of any reasons, any times, when people might choose to use cars instead of taking a train?) Because they don't have a train by their house, or it's a long drive. (Long drive to . . . ?) The train station.

7. They could get places faster. Like instead of doing like the whole day just to get to Florida, it would only take them, like 10 hours. (When are some times when people might choose to take an airplane instead of taking a car or train?) When they're going somewhere far.

8. Because they take up so much room trying to build the railroad tracks.

Emily

4. Because they could catch up to things that they needed to eat.

5. They could ride on trains. (Why would they choose to ride on trains?) Because that would help them get from place to place, because when I went to Disney World, I rode on a train.

6. They could go different places that were up here instead of down there. (What do you mean by up here instead of down there?) Like right where grass is between the roads, there could be big poles, and then there could be a road up there and then there could be something built.

7. They could to go Ohio or Florida or India.

8. There might be more people and it's much more crowded and it might be true that it's getting smaller because more people come.

Third Grade

Dale

4. The transformation changed from walking because some would get really tired and they'd have to go somewhere to get some water and they wouldn't know where, but if

they walked, it would take a long time, but if they used horses, they would get there faster.

5. They could go places on the railroad, like if they wanted to go wherever the railroad could go. (Why would they choose to do that—why would they choose to go on the railroad?) Cause it's quicker—it's not that slow. It's sort of cheap, too, and it's quicker.

6. Go faster, and they would probably go faster and they wouldn't have to run into trees or anything like some people going in branches that would hit them in the eye, and now the way roads are built you don't have to get hit or nothing—only by cars or trucks.

7. They could fly to all of the places. If they wanted to go to L.A., fly and go to L.A. (Why would they choose to do that?) Because it would be quicker. They couldn't just walk there all the way in the water. They couldn't walk.

8. It means that it makes it better because of all of the other things they don't use, but now the new things they use makes the world smaller.

Chelsea

4. A lot because they could go places more fast instead of walking.

5. They could go places easier and not have to walk, and they could go places faster, and sometimes it's fun.

6. If there were cars, they could go on the highway with the cars and you could go lots of places because cars have an engine and the engine makes the car go.

7. They could go somewhere way farther way and it didn't take that long.

8. Because there's more cars and highways and railroad tracks. (How does that make the world smaller?) There are big highways and big places so it makes it a little smaller.

Grade Level Differences

All but one of the significant relationships with grade level were linear, and in each case (Questions 4-8) the data indicated that the younger students were more likely to be unable to respond to the question and the older students more likely to provide the more sophisticated responses. Older students were more likely to say that horses allowed Native Americans to travel farther or faster, to travel without getting as tired or using as much energy, and to fight, hunt, or find food more easily; that trains allowed people to travel faster; that highways allowed them to travel more cleanly and safely; that airplanes allowed them to travel to faraway places; and that changes in transportation have made the world smaller because transportation-related construction takes up space and because we now travel more easily and are connected with more people and places. Responses that were less focused on these main ideas or that contained a

mixture of accurate and inaccurate elements typically showed no significant relationship with grade level. Finally, there was one nonlinear relationship: More kindergartners and third graders than first graders or second graders answered Question 7 simply by saying that people could now ride in airplanes (without elaborating with statements codable in subsequent categories).

Note that there was a positive relationship with grade level for stating that changes in transportation have made the world smaller because transportation-related construction takes up space that otherwise might be available for homes, parks, nature preserves, etc. Although this is a relatively immature response in that it indicates a failure to appreciate the metaphorical meaning of the statement, it also can be seen as a thoughtful response by students who took the statement literally. It is true that highways, airports, train tracks and stations, etc. take up a lot of space and thus have "made the world smaller" by subtracting that space from the total space available for other human purposes. Across our interview studies, we occasionally find positive relationships with grade level and/or achievement level for categories such as this one that are not the most sophisticated response to the question (or perhaps even are incorrect), yet represent good thinking by students who are working from very limited prior knowledge. In view of this, it is not surprising that this response showed a positive relationship with achievement level.

Achievement Level and Gender Differences

The 29 categories for coding responses to Questions 4-8 yielded 15 significant relationships with grade level, but only 7 with achievement level and 2 with gender. In response to Question 4, higher achievers were more likely than lower achievers to say that horses changed the lives the Native Americans by enabling them to travel further or to visit new places. In response to Question 5, lower achievers were more likely to talk about trains being easier or more fun to ride, whereas higher achievers were more likely to say that trains enabled people to travel more quickly. Higher achievers also were more likely than lower achievers to talk about getting places more quickly in responding to Question 6 on the effect of highways. In response to Question 7, lower achievers were more likely than higher achievers to be unable to respond to the question or to talk about planes allowing people to travel to different states or countries, whereas higher achievers were more likely to say that planes allowed people to go to farther-away places. All of these significant differences favored higher achievers, indicating that they made more sophisticated responses to this set of questions.

The gender differences indicated that 28 boys but only 20 girls said that people could get to places more quickly after railroads were built, whereas 7 girls but none of the boys talked about highways allowing people to travel up high instead of down lower. Both of these differences favored the boys, because reference to getting places more quickly was the most sophisticated response to Question 5 but reference to the idea that all highways are built high above the surrounding land was one of the less sophisticated responses to Question 6. Overall, however, the boys' and girls' responses to this set of questions were more similar than different.

Relationships Among Response Categories

Students who answered Question 4 by saying that horses allowed Native Americans to travel more quickly or to go to farther away places were more likely than other students to

answer Question 14 by saying that we wouldn't be able to get around as quickly today if we didn't have cars. Students who said that horses changed the lives of Native Americans by making it easier for them to travel without using as much energy or getting as tired or sore were more likely than other students to make a similar response to Question 5 in talking about the effect of trains. Once again, we see the "comfort" factor in certain students' responses (although surprisingly, this didn't extend to their responses to Question 7: There was no significant relationship between "comfort" responses to Questions 4 and 5 and the statement that air travel is easier, more relaxing, or more fun than previous forms of travel).

Students who said that horses changed the lives of Native Americans by making it easier for them to travel and not requiring them to get tired or sore walking were more likely than other students to later say that if we had trains but no cars we would want to live near the train station so we wouldn't have far to walk. This correlation also fits in with the "comfort' theme. The final response to Question 4 (that horses made fighting, hunting, or finding food easier) correlated with the maturity set of responses to the interview as a whole.

Students who answered Question 5 by saying that the railroad allowed people to get places more quickly were more likely than other students to make similar responses when talking about how horses changed the lives of Native Americans, about the effects of the introduction of highways and later of airplanes, and about how our lives would be different if we did not have cars today. These intercorrelations are all part of recognition of the fundamental idea that each successive innovation in travel increased the speed of travel. Besides correlating with one another, the "making travel faster" responses tended to correlate with the maturity set for the interview as a whole.

There was no parallel cluster for responses indicating that a travel innovation made it possible for people to travel farther away or to reach places that they couldn't reach before. That is, the response categories for Questions 4-8 that might have clustered into a "distance" theme did not intercorrelate as consistently as the categories that formed the "speed" cluster. Typically, these intercorrelations did not even reach statistical significance.

Some students answered Questions 4-8 by listing specific problems that no longer existed once the new innovation was in place. For example, these students answered Question 5 by suggesting that railroads allowed people to carry more things when they traveled, to have more personal space, and to avoid having to stop often to let horses rest; answered Question 7 by indicating that airplanes don't run out of gas, get flat tires, have to deal with traffic, or stop at stoplights; and later answered Question 14 by suggesting that cars are much better than horses because horses get frightened, get tired, need feeding, have to stop to rest, etc. Students who answered one of these questions by listing one or more of these specific issues were more likely than other students to answer the other two questions similarly. That is, their response style favored giving specific examples rather than broader generalizations.

Students who said that trains allowed people to go to farther-away places were more likely than other students to also say that airplanes allowed people to go to farther-away places. However, these were the only "distance" responses that correlated significantly. As noted previously, there was no clear "distance" cluster paralleling the observed "speed" cluster.

There was, however, a tendency for students who raised the issue of travel across water on one question to raise it on another. In particular, students who said that airplanes could cross water/oceans were more likely than other students to indicate that a weakness of trains is that they cannot cross water (in responding to Questions 6 and 15). These responses all were accurate for students who were thinking about lakes or oceans, but a few students expressed the misconception that trains cannot cross rivers.

Stating that changes in transportation have made the world smaller because transportation-related construction takes up a lot of space was correlated positively with the maturity set of responses to the interview as a whole, and in particular with other responses that indicated good reasoning (albeit sometimes from a limited base of prior knowledge). Here again is evidence that, given the ages and prior knowledge of the students interviewed, this was a relatively mature response.

Stating that changes in transportation have made the world smaller because we can now travel more quickly or easily, get to more places, and are more connected with other people and places also correlated with the maturity set, although not as consistently as might have been expected. This is probably because the majority of the eight responses coded in this category were for merely stating that we can travel much more quickly and easily now. Only two students said that we are now better connected with other people and places.

Rare and Unique Responses

Question 4

Kindergarten: They could get to the cowboys and "war" with them.

First grade: Says that after they acquired horses, Indians could ride them and not have to walk all the time, but adds that it might have been better to walk because "then the horse and the Indian get exercises, both of them."

Second grade: Horses helped with the work (farming?); they had less food after horses because horses made noise and scared away the buffalo.

Third grade: You can pack "luggage" on horses; horses could pull stuff that they wanted to take with them (2).

Question 5

Most of the responses to Question 5 were well captured by the categories. However, one kindergartener thought that horses and buggies were faster than trains, and two third graders made unique and insightful responses: trains could carry coal and things so that people could earn money; trains brought new jobs such as engineer or brakeman.

Question 6

Kindergarten: Test out new cars.

First grade: Highways brought businesses that provided amenities to travelers (gas, food, drinks); highways are slow because the trips on them take hours (reverse reasoning, based on the idea that you use highways only when you are going on long trips); highways allow you to drive "up high" (several other students had this idea); it is more fun to drive on a highway than to sit in a train all day; cars are more comfortable than trains.

Second grade: Cars are more fun than just sitting on a train.

Third grade: None.

Question 7

Kindergarten: So you could see things from the sky (this was one of several students who mentioned the aerial view as something that came with airplanes); planes can get up in the air and out of traffic.

First grade: The aerial view; you can get food and drinks on planes; if there was a truck full of dynamite about to blow up on the road, you could take a plane and get away from it; you can drink coffee, eat, and read on a plane; planes sometimes fly slow so that people can "stop and look in the sky;" believes that you cannot drive to Florida "because there's water" in the way, so you have to fly over it.

Second grade: You can see the clouds.

Third grade: People didn't have to take boats anymore; planes have more storage room than cars; planes go more places than a train or car can go; there are lots of seats—planes fit many people; people like the view from planes.

Question 8

Kindergarten: There's more things now than there used to be.

First grade: One first grader missed the point of the saying but showed good reasoning about how transportation extended the boundaries of the known world: "It's made the world bigger. There's more stuff in it and people would add on . . . make places like France" (i.e., extend the frontiers to create new settlements and eventually countries).

Second grade: The best response was made by a second grader who said that this saying is a figure of speech meaning that people are less isolated and more connected. This student also hinted at the concept of interdependence: "They aren't working by themselves anymore, like the Indians who had to build their own fires because they had no matches."

Third grade: This third grader is quoted for an interesting response that has part of the idea but places an overly specific (strictly local) spin on it: "It's because a lot of people go to the same place and they say the world is smaller because there's tons of transportation, so people could get from place to place and you could see people in the store and say 'This is one small world.'"

Another third grader is quoted for an interesting response that starts out correctly but then regresses to less mature reasoning: "They mean that it's easier to go from one place to another. (Why would that make the world smaller?) Back then, there was lots of grass and trees and things like that, but when these came along, people felt that the world was bigger. (Can you tell me more about that?) Back when Indians were there, the Indians thought that the world wasn't very big—that it was really small. (OK, but people say that changes in transportation have made the world smaller. What do they mean by that?) There's less room because of all the buildings and trains and airplanes and airports."

Discussion

The students' responses to Questions 4-8 were generally accurate, usually focused around big ideas, and often indicative of good reasoning even when their prior knowledge was limited. However, about 20% of the students' couldn't respond to Questions 4-6 and more than half of them couldn't respond to Question 8. Subgroups of students showed tendencies toward repeating certain themes in talking about the effects of transportation innovations. Some emphasized that the new transportation means allowed people to travel faster, whereas others did not make these generalizations but identified specific examples of ways that travel was made easier or more pleasant. Other students emphasized that trains and later planes made it possible for people to travel to farther-away places, but there wasn't as clear a "distance" cluster as there was a "speed" cluster in responses to this set of questions as a whole (and later, to Questions 14 and 15).

The students generally understood that innovations in travel typically make it possible for people to travel faster and in more comfort than before. In thinking about and responding to the questions, however, most students restricted their purview to the micro-level, talking about the experiences of the individual traveler (or occasionally, the family). References to the macro-level (effects on the nation or the world at large) were rare, as they have been in all of our studies. Students didn't mention, for example, that horses allowed the Plains tribes to follow the buffalo over much greater distances, or that railroads, highways, and airplanes transformed the nation and the world from a collection of mostly isolated settlements into a richly connected social and economic network. With the exception of one remarkably insightful second grader, the students we interviewed had very little awareness of these macro-level events.

For the most part, misconceptions were minor and infrequent. However, several students were under the impression that trains cannot cross rivers and that all highways are literally "high"—built significantly above the surrounding land. Other misconceptions included the notions that Indians found it harder to hunt food with horses because they scared away buffalo, that horse-drawn buggies were faster than trains, that highway travel is slow because it takes

hours to get where you are going, and that it is not possible to drive from Michigan to Florida because the way is blocked by a significant body of water that one must fly over.

In contrast to their generally impressive responses to Questions 4-7, the students were not ready for Question 8. More than half could not respond to it and most of the rest understood it literally rather than metaphorically, so they said that the world has become smaller because transportation-related construction takes up a lot of space. Only two students grasped the metaphoric meaning and spoke of people now being more connected to one another, one completely and one partially. Poor performance was not unexpected here because primary-grade children usually have difficulty with metaphor. However, subsequent data make it clear that this was not the only reason that the students struggled with this question. On this and all of our interviews, the students displayed difficulty imagining and talking about the macro-level of social phenomena.

The grade-level analyses indicated that the older students generally had more, and more accurate or specific, knowledge than the younger students. The achievement level and gender differences were much less frequent and noteworthy. The general trend was for higher achievers to be more able to respond and more likely to respond more accurately or specifically than lower achievers, but these differences rarely reached statistical significance. The only significant gender differences indicated that girls were more likely than boys to make "comfort" responses in talking about the advantages brought by travel innovations.

The Historic Effect of Rivers, Railroads, and Mountains on Travel

Questions 9-11 addressed aspects of students' understanding of the principle that human populations tend to concentrate along travel routes and be bounded by significant geographical barriers, especially mountains.

Question 9. Long, long ago, people built cities near oceans or on big rivers. Why was that?

Question 10. Later, people built cities along railroad lines. Why was that?

Question 11: At one time, mountains made it hard for people to travel. Most people didn't even try to cross mountains, but now we cross them all the time. Why is it easier now?

Almost a third of the students were unable to say why people built cities near oceans or on rivers. Of the rest, 27 said that they wanted to use the water for drinking or washing, 24 that they wanted to swim or play in the water, 23 that they wanted to be able to travel by boat or ship, 15 that they wanted to get food (fish) from the water, and 8 that they wanted to view the beauty of the water or listen to the sound of the waves. Thus, a majority of the students able to respond to the question emphasized the more important (functional) reasons (eating, drinking, travel), but some mentioned only recreational or aesthetic reasons.

About a third of the students also were unable to say why people built cities along railroad lines. Of those who were able to respond, 24 said simply that the people wanted to ride the train or go places, 24 that they wanted to be able to get to the train easily, 15 that settlements

were built along the tracks so the trains would have a place to stop and people would have a place to board them, and 9 that the people liked to watch the trains or listen to their noises. Once again, the majority of the responding students mentioned functional reasons, but a few mentioned only aesthetic reasons. At least some of the responses focusing on the ideas that settlements were built along tracks to provide trains with a place to stop contained elements of reverse reasoning. That is, some of these students thought in terms of the process beginning with the building of the tracks (for no apparent reason) and then settlements being built along the tracks primarily to serve the needs of the trains, instead of realizing that tracks were laid to link communities to which people wanted to travel and the trains were operated to serve the needs of the people in these communities.

Almost a third of the students also were unable to explain why it is easier to cross mountains now than in the past. Furthermore, 22 students responded to Question 11, at least initially, within the context of mountain climbing. That is, instead of talking about modern vehicles, they talked about the availability of special climbing shoes, ropes, backpacks, hooks, and other climbing equipment. Only a minority of the responses focused on modern vehicles: 33 students said that we now drive cars over mountains or ride trains through them in tunnels, and 10 said that airplanes now fly over mountains. Finally, 9 said that mountains are easier to cross now because they are smaller than they used to be (worn down over time) or less dangerous (there is less snow than in the past, or there are fewer falling rocks because most of the rocks have already fallen). The following examples from average-achieving boys and girls are representative of the responses from students across the four grade levels.

Kindergarten

Jered

9. I don't know.

10. I don't know . . . for trains. (Why would they want to be by trains?) Because the train could stop and you could hop right on.

11. Because . . . I don't know . . . because there's . . . there's a road at the top.

Kate

9. Well, because if they didn't have any water, they would have to have water or they couldn't catch any fish.

10. Well, because so they could drive on it and ride on it.

11. Because they can cross it if they wanted to so they don't have to walk. They could go on a bus or a horse and you could go in a car or a bus.

First Grade

Chris

9. Because they had more because they found some land and some water and they put and like . . . I forget what it was—the Eiffel Tower was built in water a little. So then it was in the land and water.

10. So they didn't because the trains couldn't just stop where the people were. They could just when they said "all aboard" and they all come on the train.

11. They could fly over. (Are there any other reasons why people can cross mountains all the time now?) Because back then they didn't have these hook things to climb up them and so they can go fall down the things, the Rocky Hills.

Lauren

9. Well, because they built like really tiny houses and they don't have water and they don't have electricity and sometimes they don't even have sidewalks. They only have grass, so they could only get out on their driveways. (Can you think of any other reasons why people would want to have cities near oceans or big rivers?) They could go swimming if they didn't have a swimming pool and if the water's clean enough, they could get a drink.

10. Because they didn't know they couldn't go to any other houses. And they could like . . . I'm not sure. (Why would people want to live near the railroad line?) Because they could like go back on the railroad and come back on the railroad. I don't know what else.

11. Well, I think that all the animals that are around, you know, they like brushed their feet marks off there.

Second Grade

Mark

9. So then they could just like get water, right from there, because they don't like live by the grocery store. They have to drive a ways. (Can you think of any other reasons why people would want to live near the water?) To wash their clothes in it.

10. Because if they didn't have a car or anything, they could just like, go to the train station and then they could go on a train.

11. Because like people went up there, and like knocked down rocks, so then the cars can go up there. And they like built roads that went like this, so then they could go up.

Emily

9. Because they might want to live near the ocean so they can go swimming and if they go way out, they might see some fish, because one time when I went to the beach, an alligator got swept into the ocean so everybody had to stay out of the water.

10. Maybe because they like to see the trains go fast and they like the noise and they like seeing the black within the little orange.

11. Because you keep on practicing and practicing until you get the hang of it and then you can climb up easier.

Third Grade

Dale

9. Maybe because they could hide there or they could just go there to a restaurant like if they're hungry, or they could let sailors and people that go all over the world like my grandpa and grandma. Sailors could come there when they're like thirsty or hungry or maybe if they're tired. They could put their boats in and go there because it would be better for them.

10. Because buses and trains—they could decide what one they wanted to do so there would be more traveling instead, or they could just use one of those two. The train would be quicker.

11. Because we have airplanes. It's easy. You just get on an airplane and you could just land on a hill. It'd be easy.

Chelsea

9. Because if they didn't have water, they could get water from oceans and the rivers, and they could fish.

10. Because if they had to go on the train, then they could get on it easier when they wanted to.

11. Because they used to try to walk up mountains and it's really hard because there were oceans right by the mountains, but then people built roads and it makes life easier because the cars can go up the roads instead of you walking across the mountains.

Grade Level Differences

The response categories for Questions 9-11 showed fewer significant relationships with grade level than might have been expected, although all of the relationships that did reach significance were predictable. For Question 9, younger students were more likely to be unable to

respond to the question and older students more likely to say that people built cities near oceans or on rivers because they wanted to use the water for drinking or washing. For Question 10, younger students were more likely to be unable to respond and older students more likely to say that people built cities along railroad lines so they could get to the train more easily. For Question 11, younger students were more likely to be unable to respond or to say that it is easier to cross mountains today because they are smaller or less dangerous than they used to be, whereas older students were more likely to say that we can drive over mountains or take trains through them now. The remaining categories for responses to Questions 9-11 not only did not show significant relationships with grade level but did not even show suggestive trends.

Achievement Level and Gender Differences

The 16 response categories yielded seven significant relationships with grade level but none with achievement level and only one with gender. The gender differences indicated that eight boys but only two girls mentioned the ability to fly over mountains in airplanes as one reason why it is easier for us to cross mountains today than in the past. This difference was a stylistic one, balanced by a nearly significant different in the opposite direction suggesting a tendency for more girls than boys to say that today we can drive cars over mountains or take trains through them. Again, the boys' and girls' responses are more similar than different.

Relationships Among Response Categories

The response that people built cities near oceans or rivers because they wanted to be able to use the water was part of the maturity set of responses to the interview as a whole. In addition, it was correlated with a number of other responses that indicated a tendency to get right to the point of the question: saying that horses made it easier for Indians to fight, hunt, and find food; that highways made it easier for people to get places faster; that if we had trains but no cars we would have to deal with the hassle and crowding of train travel; that building a highway through a small town would bring both positive and negative consequences; and that people who use taxis do so because they do not have a car to use. This direct and generalizing style of response contrasts with the "specific example" style described previously.

Students who made aesthetic responses to Question 16 (people built near the water to view its beauty or listen to its sounds) were more likely than other students to also make aesthetic responses to Question 17 (they built along rail lines because they like to watch the trains or listen to their sounds).

Students who mentioned airplanes flying over mountains in responding to Question 11 were more likely than other students to mention planes in responding to Question 26 (identifying forms of transportation found in big cities).

Rare and Unique Responses

Responses concerning location of settlements near oceans or rivers were generally poor. Many of the students who mentioned travel by boat or ship were thinking of only casual local

boating, perhaps for fishing or swimming, not about transportation linking the settlement to the rest of the world.

Question 9

Kindergarten: So they could see if anyone was coming to kill them; so their animals could live—they needed water (apparently not thinking about human needs for water).

First grade: That was the only open land (presumably the rest was covered with thick forest).

Second grade: They wanted to keep cool in the summer; the early Europeans wanted to "explore from edge to edge" rather than walk the interior of the country.

Third grade: They could earn money from fishing; the shoreline was the only open land for building settlements; port cities were needed to provide recreation and services to sailors and travelers (reversed reasoning, similar to the idea that settlements were built along rail lines to service the trains); so they could have some natural resources; so they could provide services to travelers (another reversed reasoning response).

Question 10

Most responses were well described by the categories, although several students assumed that people would have cars (i.e., they would drive to the station and then take the train). The students generally had trouble with questions that posed hypothetical situations, often responding with explanations that included reversal of causality.

Kindergarten: None.

First grade: Cities were built along rail lines so that the trains could stop and the driver could rest and get refreshments; people ride trains to go to cities and do things, so you would have to build cities along the railroad.

Second grade: None.

Third grade: So trains could stop and get coal; to get coal and all of the things that trains transported.

Question 11

Many students answered this question in terms of individuals climbing mountains rather than people traveling in vehicles.

Kindergarten: People are bigger now and can do more than the cave people could; because ways to cross the mountains have been discovered.

First grade: People are stronger now; you can grab the rocks easier because they are stiffer now; there are no more bumps or monsters; they cut down the trees and made a road; people were more likely to fall back then (unexplained further).

Second grade: None.

Third grade: Now we have ski lifts; the mountains aren't as big now; the mountains aren't as steep now; you can use a glider to get up.

Discussion

The students' responses to Questions 9-11 were generally accurate or at least defensible, but few of them showed much awareness of the big ideas about the interactive relationships between transportation and human settlement patterns that lay beneath these questions. In the first place, about a third of the students were unable to answer each of them. Furthermore, although the students who did respond were able to generate various reasons why people might want to locate near water, only a minority displayed awareness that water is necessary to human survival and only a few conveyed any awareness that in the distant past, much exploration and long-distance travel was done on waterways.

Similarly, the students able to respond to Question 10 generated various reasons why people might want to build cities along rail lines, but few of them showed any awareness of rail lines as vital links to other communities, sources of access to goods and markets, etc. during those times. Finally, the students who were able to respond to Question 11 generated various reasons why it is easier to cross mountains today than in the past, but few of them showed any awareness of mountains as significant barriers to transportation until the relatively recent past. The response patterns to these questions once again illustrate the students' focus on micro-level but not macro-level aspects of the topics addressed.

Fewer group differences were observed for these response categories than for most other sets of categories. Significant relationships with grade level appeared less frequently than might have been expected, and there was only one significant relationship with achievement level and one with gender. Perhaps this is to be expected in situations like this where even the oldest students have not yet developed much awareness of the big ideas that prompted the questions, yet the questions are answerable through commonsense reasoning focused on people's motives for action at the micro-level.

Wheeled Vehicles Through History

The next four questions further probed students' understanding of historical developments in transportation. Question 12 asked why the wheel was an important invention, to see if students understood its basic nature and the magnitude of the changes it brought. Question 13 asked whether the Pilgrims might have been able to drive across the country if they had cars with them. This was designed to see if the students understood that North America at the time was a heavily forested wilderness, so that cars would be relatively useless until roads were constructed. Question 14 asked how our lives would be different today if we still had to

rely on horses and wagons instead of cars. We were interested to see if students could go beyond merely noting that travel would be slower and less convenient, in order to show some understanding of some of the many ways in which society would be different (smaller and more isolated communities, different profile of major industries, etc.). Question 15 asked how our lives would be different if we had trains (but still no cars). Again, we were interested to see if the students would show some understanding of the many ways in which society would be different.

Question 12. Why was the wheel an important invention? (What could people do after the wheel was invented that they couldn't do before)? (If student starts talking about cars, ask **What about before cars were invented—why was the invention of the wheel important?)**

Question 13. If the first Pilgrims to come to the New World had cars—could they have used the cars to drive across the country? (If yes, **How would they have done it?)** (If the student says that trees were in the way, ask **What if they cut down the trees?)**

Question 14. What if there were no cars today? How would our lives be different if we only had horses and wagons to help us get around?

Question 15. What if we had trains but no cars? . . . How would our lives be different? . . . How would that affect where we lived? . . . How would we shop if we only had trains? . . . How would it affect where we went on vacation?

When asked why the wheel was an important invention, 18 students were unable to respond. A majority (57) of the rest said that wheels are needed for cars, planes, or other vehicles. In addition or instead, 27 said that wheels allow us to move things more easily without having to drag them, 21 that they allow us to travel more easily, and 20 that they allow us to go faster than we can in non-wheeled conveyances. All of these responses are accurate and most show appreciation of the fundamental importance of the wheel.

The students had much more difficulty with Question 13. Only 15 of them noted that the Pilgrims would not have been able to drive across the country in their cars because forests/lack of roads would prevent them from doing so. Of the remaining students, a majority (57) incorrectly said that the Pilgrims could have driven across the country if they had cars, and the other 24 either said that they were not sure or made reference to barriers such as rivers and lakes, mud or snow, or lack of gas stations (without mentioning the fundamental problem of roadless wilderness).

When asked how our lives would be different if we only had horses and wagons today, 29 students were unable to respond (a surprisingly high number). Those who did respond said that we wouldn't be able to get around as quickly (42), said that it would be harder to get around (23), listed troublesome characteristics of horses, such as that they get frightened, get tired, or need feeding (14), or simply stated that we would have to walk more (12). Few of them conveyed any indication that they were visualizing major differences in society as a whole.

When asked how our lives would be different if we had trains but no cars today, 25 students were unable to respond (again, a surprisingly high number). Among those who did respond, the most popular responses were that we would have to walk more (32), travel would be inconvenient because trains usually don't stop at the exact place that you wish to reach (23), we would want to live near the train station (20), travel would be slower because of all the train stops (19), and we would have to put up with the hassle and crowding involved in train travel (17). Other responses included the ideas that speed of travel would be improved because trains are faster than horses (8), trains would make a lot of noise (8), it would cost money to ride the trains (7), and we would not be able to cross water because trains cannot do so (7). The following examples from average-achieving boys and girls are representative of the responses from students across the four grade levels.

Kindergarten

Jered

12. For driving cars. (Yes, but what about before cars were invented? Why was the invention of the wheel important?) They could be for planes too. It's important to drive somewhere else to another place.

13. No. (Why not?) Because cars weren't built then. (You're right, but let's pretend that they had cars. Could they have driven those cars across the country?) Yes.

14. I don't really know.

15. Don't have to drive. You just sit on the train and . . . I forget what else. (Well, if we had trains and no cars, how would that affect where we lived?) You could get to your home. (How would we shop if we only had trains?) The train driver could drive you to the store. (How would it affect where we went on vacation if we only had trains?) By train. I'm going on a jet to Florida—a jet plane.

Kate

12. So the people don't fall off in the car . . . so the car doesn't fall down. (Yeah,, the wheels stop the car from falling down, but what about before cars were invented? Why was the invention of the wheel important?) Because so you can drive.

13. Yeah. (How could they have done it?) Well, they could go around and then they could bring the boat and some people could ride the boat and then if they're by the part where there's the water, then they could ride on the boat. (OK, so they've got the cars on the beach here. Could they drive them across to Michigan? Could they do that?) Yeah, if there was a part where you could go and drive. (How would they do that?) Like build a ledge to put those on.

14. Well, they could go across a lake with a horse dragging a wagon. (If we didn't have cars, how would that change our life?) I don't know.

15. We could use a train that has tracks. (How would that affect where we lived if we only had trains and didn't have cars?) They could give you a ride and take you home. (Yes, but the train has to stay on the tracks.) Well, . . . I don't know. (How could we shop if we only had trains?) They could drop you off at a place and they would come back. (How would it affect where you went on vacation?) You could walk.

First Grade

Chris

12. Because they can . . . because the wheel is rubbery and they're made of circles and they didn't have no ends. That means they can roll. They put them on the cars and you could drive in and they rolled. (Well, why was the invention important even before cars?) I don't know. Because they could drive on cars faster. The wheels can stop wherever they want and they can't like roll down when they're . . . like if there's a circle right here, and I pushed it, it would go right there and it would go round and round and drop.

13. Yeah. (How would they have done it?) They could drive up mountains if it was a very powerful car. They could drive up mountains and go down them and go wherever they wanted.

14. It would be slower because the horses can't go that fast. Like if you wanted to go to Florida and it's a one cattle thing, you could just have another horse and if it was a baby, he couldn't ride it.

15. Because it's on a track and they don't like fall right off of the track. (Well, how would that affect where we lived?) I don't know. (Well, how would we shop if we only had trains?) You could just go there and you can go and you can pick some stuff up and pay for it and the train would be gone. Then you'd have to wait for a little while and the train would come back. (Now, how would it affect where we went on vacation?) You could go wherever you wanted and you can make stops by going "OOHH" and it stops and you can just go off. (So would it change where we went on vacation very much?) Yeah. (Why?) Because you pull a cord.

Lauren

12. Because it could take people places and stuff. (What could people do after the wheel was invented that they couldn't do before?) Well, they could get places faster and they could take people like longer places to go. (Why could the wheel help people go longer—longer places and go faster?) Because the wheel can roll because it's a circle, I think.

13. They could drive. (OK. Would they have any problems using the cars to drive across the country, long, long ago?) I see a little bit of problems. (What would their

problems be?) Because they had to learn to drive and stuff. And they had to have a license plate and they had to learn how to drive, too.

14. They would like have to use horses and wagons and they invented cars. I think they would be really happy because cars can go faster than wagons and horses. (OK. Imagine if your family didn't have a car. How would your life be different if you didn't have a car?) Well, we couldn't get places faster and we would have to walk and we would have to walk to school and we would have to walk to work and we would have to . . . you can run in shoes if you want to. Sometimes people in the olden days—they wanted cars more than horses.

15. Well, we couldn't get places a little more faster and I think that people would be unhappy. (You think people would be unhappy if you had trains but no cars and so it would be faster to go on a train or faster to go on a car?) Faster to go on a train. (If you didn't have a car and there were only trains, where would you family want to live, do you think?) By the railroad track. (Why would they want to live by the railroad track?) Because when the train goes by they could get there faster. (How would we shop if we only had trains?) Well, we could like go get other places. (What sort of other places?) We could go to stores and we could go to the mall. I think that's all. (Would the train stop at the stores in the mall?) Well, I don't think so. They could call the train, though. I think the train has a phone in it and I think they could like call the train and that store had a phone in it. (How would it affect where we went on vacation if we didn't have any cars—if we only had trains?) Well, we could get places a little more faster than trains. (Would you go on vacation to a different place if you were going on a train?) Yeah. (Where would you go if there were only trains?) Chicago, because they sell American Girl stuff and I like American Girl (dolls).

Second Grade

Mark

12. They could go places. (Why did the wheel make it easier for people to go places?) Because they couldn't like just go on the bottom of a train, because it wouldn't go, so they had to build wheels to fit on the track.

13. Yeah. (OK. How could they have done that?) Like they could just drive to places, and then they could build roads on there, and they go and they could work on that, and then somebody else could drive their car up there and then do work on that.

14. That would take a pretty long time to get places.

15. You would have to walk if you lived far away from a train station. You would have to walk there. (Where would we want to live if there were trains but no cars?) Close to the train station. (OK. How would we shop if we only had trains?) Then you'd have to like get dropped off, and then you'd have to walk to the store. (Why would you have to get dropped off?) Because trains like just don't go straight to the stores. (How would it

affect where we went on vacation if there were only trains, but no cars? Would we be able to go to all the same places for vacation that we can go to now?) No. (Where do you think we wouldn't be able to go?) Like to Florida, because they wouldn't have enough coal to last that long.

Emily

12. Because without wheels our cars and our carriages wouldn't be able to go any place. Somebody would have to hold on to the end and drag it.

13. They could use them to go to the store but they couldn't use them going across the sea. (Why not?) Because the car might sink. (What about places where there wasn't water—could they use the car?) Yeah, because at the beach one time the water got dried up because there was too much sun and cars went across the sand. (What about when they went in further—went inland away from the beach—could they have driven away from the beach?) Yeah.

14. I don't know.

15. Because then we'd be going a lot faster. (Why would that be?) Because trains go a little bit faster than buses and cars. (If we didn't have cars and only had trains, how would that affect where we lived?) You'd still live in the same places because maybe the railroad might be really close to our house and it goes past our house and it could stop right by our house and then we could get off. (How would we shop if we only had trains?) The train could drive us to the store and then it could stop and rest and then we could go in the store and get what we needed and then we could come back out and get back on the train. (If we only had trains, how would that affect where we went on vacation?) They might drive a little bit and if there was another train, then we could get on that train and it could go to that place.

Third Grade

Dale

12. So they could land. If they didn't have a wheel, how would they be able to land? If they have a wheel, they can just land. (What about before airplanes—they had wheels.) They had stone wheels, I think. (Why were they important?) Because it would be easier to travel. If we didn't have them, how would you be able to travel? Or the engine. You need engines, too. (But what about before engines were invented—we still had wheels. Why was the wheel important?) Because you could travel easier if you had a wheel.

13. Maybe. (How could they have done it?) They could just drive over on that. It would be easy.

14. It'd be bad. You couldn't travel. You'd have to use something . . . (If we only had horses and wagons to help us get around, how would our lives be different?) Sort of

good, sort of bad, because some people don't know how to ride horses, like me. Some people have never rode them.

15. You'd use the train, and it'll go faster. (If we only had trains and no cars, how would that affect where we lived?) It'd be bad probably. (Why?) Because if we didn't have cars, we couldn't go anywhere. Probably we could walk. (How would we go shopping if we only had trains?) You'd have to tell that train to go to whatever store you wanted and they'd have to have carts for carrying stuff, and once they had their hands full, let somebody else carry it back to the train or you could carry it back to the train. (So how would having trains affect where we went on vacation?) Sort of bad, but it wouldn't be that bad because you couldn't go through water—you'd have to go all the way around it.

Chelsea

12. Well, it was an important invention because sometimes you have to go somewhere right away and you don't want to be late. (Why does the wheel make it faster?) Because the wheels can go on the road and the engine helps the wheels go and it's really easier.

13. Well, it depends because they might get stuck in the sand and if they go in the water, then the car will sink and they might die. But if they had roads then, then they could go across the ocean. (If they didn't have roads, would they still be able to go across the country?) Yeah, sometimes. (How would they do that?) If there wasn't any snow and if there wasn't any mud puddles and it was summer, maybe they could because they wouldn't get stuck, but sometimes they could, sometimes they can't.

14. It would be really different and it would be really hard to go somewhere and if I went to Florida, then I would have to either have a horse or a wagon and would take really, really, really long, and today, it's like way, way easier.

15. You couldn't go to the exact place, like at your friend's house where she lives in Florida. We would have to have a car to drive from the railroad track where it stops. (If we only had trains, how would it affect where we lived?) You couldn't go to the exact place that you wanted and sometimes you would have to walk like to your friend's house from the railroad train where it stops. (How would we shop if we only had trains?) Sometimes we could walk but it would be really long and sometimes we can take only a few things on the train and then you could only get a little stuff at a time. (How would it affect where we went on vacation? You talked about your friend in Florida. Can you think of other ways it would affect where we go on vacation if we only had trains and no cars?) No.

Grade Level Differences

Younger students were more likely to be unable to respond to Question 12, whereas older students were more likely to say that wheels allow us to move things more easily without having to drag them, that we can move faster on wheeled conveyances, and that we can travel more easily in general. Surprisingly, there were no significant relationships with grade level for any of

the categories for responses to Question 13. Furthermore, there were only very weak trends suggesting that older students were more able than younger students to handle this question about whether Pilgrims could have driven cars across the country. We expected more of the older students to say that this driving would not be possible because there were no roads through the forests.

Younger students were more likely to be unable to respond to Question 14 asking how our lives would be different if we only had horses and wagons today, whereas older students were more likely to say that it would be harder to get around or that we wouldn't get around as quickly. For Question 15, younger students were more likely to be unable to say how our lives would be different if we had trains but no cars, whereas older students were more likely to say that trains would be faster than horses, that we would have to pay to ride the trains, that we would have to walk more, that travel would be slower because of all the train stops, that train travel involves crowding and hassle, and that the travel would be inconvenient because the trains don't stop at the exact place you wish to reach. In addition, there was a nonlinear relationship for stating that the trains would make noise. This response was made more by first graders than by students in the other three grade groups.

In general, the grade-level data from Questions 12, 14, and 15 match expectations in that the younger students were less able to respond and the older students gave more of the more sophisticated responses. However, the data for Question 13 show a surprising lack of development across the K-3 range in the ability to access and reason from an image of North America as a wooded wilderness at the time of the Pilgrims' arrival.

Achievement Level and Gender Differences

The 23 response categories for Questions 12-15 yielded 16 significant relationships with grade level but only five with achievement level and none with gender. Three of the five relationships with achievement level were linear and predictable: lower achievers were more likely to be unable to respond to Question 12, whereas higher achievers were more likely to respond to this question by saying that the wheel was an important invention because it is needed for vehicles, as well as to respond to Question 15 by saying that travel would be inconvenient if we had trains but no cars because trains usually do not stop at the exact place that you wish to reach. The other two relationships with achievement level were nonlinear, indicating that average achievers were more likely than other students to say that the Pilgrims could have driven across the country if they had cars with them, and less likely to say that they couldn't make this drive because trees/forests would be in the way. This was mildly surprising, in that we might have expected lower achievers rather than average achievers to show this pattern of response to Question 13. Overall, the responses to Questions 12-15 were more notable for their similarity than their differences across achievement level and gender groups.

Relationships Among Response Categories

Responses to Questions 12 and 13 did not show particularly noteworthy correlations with responses to other questions. Students who answered Question 14 by saying that we wouldn't

get around as quickly if we did not have cars today were more likely than other students to mention the speed of travel in responding to earlier questions about the effects of travel innovations. Also, students who answered Question 15 by saying that trains cannot cross water were more likely than other students to mention the issue of crossing water when talking about forms of transportation in response to earlier questions. The only other noteworthy intercorrelations involving categories of responses to these questions were tendencies for the more sophisticated responses to correlate with the maturity set for the interview as a whole.

Rare and Unique Responses

Question 12

Most students answered this question in terms of what wheels do today (e.g., on cars), not in terms of how the invention changed the world at the time. There were only a few unique responses. One second grader showed reverse reasoning by stating that if the wheel had not been invented, there would be no use for cars. One third grader said the wheel made it possible to open a curtain faster (using pulleys) and eliminated the need to use a bar to turn vehicles. Finally, another third grader also showed reverse reasoning in stating that "a car without wheels can't drive, and they probably made cars before wheels, so they had to invent the wheel."

Question 13

Many students initially answered yes to this question but then started talking about the problems coded in subsequent categories. Some of these students eventually reasoned through to the idea that the Pilgrims could not in fact drive across the country, but most did not.

Some of the codes for mentioning the problem of crossing water referred to the Atlantic Ocean part of the trip. The interviewers sought to clarify this with the students and then go on to talk about what the people would do after they reached America.

Kindergarten: None.

First grade: This first grader is quoted as a student who saw certain problems but not others and did not draw the "no" conclusion: "Yes, by driving. If they didn't have enough gas to go all the way, then they could go and get some gas and drive again. (Would they have had any problems trying to drive across the country?) Yes, their car would get stuck a lot because there wouldn't be any roads or any sidewalks back then and the cars would get stuck in the mud. So that's why they need to make the road. (OK, can you think of any other problems?) There was rocks and dirt that would splash on the window and it would be hard to see out the window."

Second grade: Here is a similar quote from a second grader: "Yes, they would go from one place to another. Like if they were in Florida, then they would drive around to all the states in the country. They would be able to do it fast with a car. (Do you think they might have had any problems trying to do that a long time ago?) Yes, they would have to stop at gas stations, and they wouldn't have them a long time ago, and sometimes they would need like stores to buy batteries and stuff."

Third grade: Travel would be slow because Indians would keep stopping them wanting to trade; they would have to go in the summer when the car wouldn't sink in snow or mud; they could drive on Indian trails or wagon trails.

Question 14

A few students who liked horses liked the idea of having horses and wagons to travel.

Kindergarten: We wouldn't have to make car payments; travel would be boring because you would spend all your time looking for water and food (for the horses).

First grade: Travel would be dangerous because you can fall off a horse; moving things would be harder because wagons can only carry small loads; travel would be bumpy and uncomfortable; some people might be allergic to horses and have to use bikes instead; trains go faster than horses; you would be exposed to the elements when riding horses; trains are noisy and bumpy and the noise gives you a headache.

Second grade: You would have to replace horses more often than cars because horses die; kids wouldn't get as much exercise because they would be riding horses instead of bikes; people would have to learn how to "drive" horses (one of several students who spoke of initial confusion due to the need to learn how to steer and ride horses). This second grader is quoted as a confused response: "I don't think that would be a very good idea to not invent a car. If we didn't have cars, we would always have to live out in the country to have horses, because the law is that you can't have horses in the city."

Third grade: You would be cold riding in the winter time; every now and then you would hear this gallop trot past you.

Question 15

Most answers were sensible as far as they went, but many students clearly did not realize the scope of the changes in society and everyday life that would occur if we had trains but no cars. Most seemed to think that most things would be the same except that we would be riding trains instead of cars. However, a few references to broader differences appeared in some of the rare and unique responses.

Kindergarten: We wouldn't be able to travel; we would shop at the railroad tracks; we wouldn't be able to shop (2); we would have to grow our own food; they would put train tracks by the grocery stores (reverse reasoning).

First grade: We'd all live in the train station and there would be no schools because schools don't have railroad tracks; trains are noisier but faster than cars; trains are harder to stop; we would want to live far away from the train station because of the noise; they would build train tracks to the stores; they hadn't invented shops when they just had trains, or if there were shops, they only sold peanuts; they would have to make a lot of tracks by the stores so they could bring the trains there; we would have to live on the train (in the station?) and there would be a

shopping market in it; stores could call the trains (trains had phones in them) to come when we needed them, like cabs; you couldn't shop, or not very often; they would build tracks next to the stores.

Second grade: It would be bumpy riding; you wouldn't be able to listen to the radio or have air conditioning when you traveled; there would be more room to move around and do things than there is in a car; you could only go to places that you don't want to go to, like if you wanted to go to the store but the train took you to Utah; there would be more pollution; there would be more bike riding (several students said this); they would have to build all the train stations near the stores; every train would have to lead to at least one store; maybe there would be special shopping trains that went to shopping centers; you could only go as far as the train would take you until it rain out of coal.

The following second grader is quoted for an unusually good response: "We wouldn't be able to get off the tracks like cars can. Cars can go anywhere on roads but trains only can go on tracks wherever they go. (So how would that affect where we lived?) We would have to live by the railroad station, but because we have cars today, we can live anywhere. (How would we shop if we only had trains?) We would have to build all of the stores close to the train tracks. (How would it affect where we went on vacation?) It would have to be someplace close to the railroad tracks."

Third grade: Trains cannot go to faraway places because they break down; they would have carts at the stores that you could use to take your stuff to the trains; you couldn't shop because trains can't stop at stores; they would have to build all the train stations near stores; describes a train trip to the mall, where you pull the cord to tell the driver where you want to get off, just like a bus; you couldn't go on vacation—you'd have to walk everywhere; you couldn't go to faraway places for vacations.

Discussion

Although most of what students said in responses to Questions 12, 14, and 15 was accurate as far as it went and few misconceptions were expressed, the students' responses to these questions were limited in at least two respects. First, 18, 29, and 25 students (respectively) were unable to provide substantive responses to these questions, which we found surprising given the concrete nature of transportation. Second, the vast majority of the responses were confined to micro-level descriptions of the use of the transportation modes involved, showing little or no awareness of the macro-level changes in society at large that were stimulated by the invention in question. Few students showed any awareness of the fundamental and far-reaching importance of the wheel or of the ways that society at large (not just personal travel) would be different if we did not have cars today and were restricted to horses and wagons or even to trains. The students did not yet have enough knowledge of social history or the effects of inventions on everyday living to prepare them to address the macro-level aspects of these questions.

Question 13 proved even more difficult for them. More than half (57) said that the Pilgrims could have driven across the country if they had cars, and another 24 either were unsure or made reference only to problems such as mud, snow, or the lack of gas stations. Only 15

students conveyed clear understanding that North America was a heavily forested wilderness at the time.

The response categories for Questions 12, 14, and 15 showed predictable relationships with grade level but very few relationships with achievement level or gender. None of the response categories for Question 13 showed significant relationships with grade level, achievement level, or gender. This was one of the few instances in any of our interview studies in which this has occurred. We found this surprising, because ordinarily the older students display more historical knowledge and the higher achievers display more ability to reason their way to substantive responses even when their relevant knowledge base is very limited.

The labels for the response categories for these questions may give the impression that the students' responses were more sophisticated than they actually were. However, when one inspects the quotations from the eight average-achieving students used as examples, along with some of the responses and quotes in the section on rare and unique responses, it is easy to see that the responses were focused on the micro-level, particularly on the comfort and convenience of the traveler.

Across the last several sets of questions, it is clear that the students were more aware of water than of mountains as formidable barriers to long-distance travel. Also, they were much more heavily focused on personal travel than on the transportation of goods or raw materials. Finally, several interesting misconceptions or examples of reversed reasoning occurred, especially with respect to the reciprocal relationships between the development of travel routes and the location of settlements along these routes. In general, the students thought more in terms of settlements being built along the routes as service centers for travelers and their vehicles than in terms of travel routes (highways, railroad tracks) being constructed to facilitate transportation between pre-existing settlements.

The Effect of a Highway on a Small Town

Question 16 asked students how a big highway built through a small town out in the country would affect that town. We wanted to assess students' awareness of the many changes that would occur, both good (improved economy, better access to other communities) and bad (congestion, noise, pollution).

Question 16. Suppose you lived in a small town out in the country and a big highway was built right through it. How would your town be different after the highway was built? . . . How would it be better? . . . How would it be worse?

More than 30% (26) of the students were unable to respond to this question, even though it doesn't appear to be very challenging. This again underscores the difficulty that young children tend to have with hypothetical questions.

Of the 70 students who did respond, most emphasized the negative effects of the highway: more or more dangerous traffic and more accidents (36), more noise (24), displacement of people or destruction of houses, parks, or nature in general (17), or other

negative outcomes such as pollution, dust, bad smells, or barriers to local travel (10). However, 29 students indicated that the new highway would allow people to get to other places more quickly or easily, and six noted that the highway would stimulate construction of more houses and other buildings. Both positive and negative outcomes were mentioned by 20 students.

The following examples from average-achieving boys and girls are representative of the responses from students across the four grade levels.

Kindergarten

Jered

16. I don't know. (Would your town be better or worse if it had a highway through it?) Better. (Why would it be better?) Because you could get to your grandma's and stuff.

Kate

16. You could drive on it. (How would your town be better?) Well, life would be weird and stuff. (How would it be worse?) If it didn't have any trees and no animals and no cars and no trains. (But you're putting in a highway, so how would it be worse if they put a highway in?) That would be good because people could drive on it.

First Grade

Chris

16. Because you could drive cars on the road. (In what ways would your town be better?) You could like turn and then you could go straight and you can go fast. (And how would your town be worse?) Worse? (Yeah, with this big highway built right through it.) Then other people probably pressured you [referring to the pressures of driving in traffic?].

Lauren

16. I think we could go faster on cars. (Why would you be able to go faster?) Well, because the highway is where people can go faster on cars. (OK, how would your life be different if the highway was built through your town?) They would be better. (Would there be anything that would be worse if you had a highway running through the middle of your town?) No.

Second Grade

Mark

16. There would be like a lot of cars going by, and you like couldn't play street hockey or stuff like that. (OK, so there'd be a lot of cars going by. Anything else that would be different?) No. (Well, how would it be better? Are there any ways it would be better for your town?) No. (Anything you can think of that would be worse once you had the highway

in your town?) That it would be really busy and if you lived by a dirt road, then all the dust would get in your eyes if you were going out in your driveway.

Emily

16. It might be different because you're used to being down instead of up on the highway. (In what ways would it be better once you had a highway?) Because then you could go up and look down and see the top of your house that you hadn't seen before, or you could see far away, because when I was up on the highway, I could see a river and lots of houses. (In what ways would it be worse if they built the highway through your town—how might it be worse?) Because you might be afraid that if lightning and thunder struck really hard, then it might fall over and it might bump your house.

Third Grade

Dale

16. Sort of bad, sort of good—good that cars could go through stuff, but cats and animals would walk through and if we're lucky enough to have brakes we could stop.

Chelsea

16. It would be really noisy and it would be easier to go on the highway but it would be really noisy and there wouldn't be any peace and quiet so you couldn't hardly get any sleep because of the cars going past.

Grade Level Differences

Younger students were more likely to be unable to respond to this question. Older students were more likely to say that the highway would increase the noise level, increase traffic and accidents, and bring other negative outcomes; to note that it also would allow people to get to other places more quickly or easily; and to mention both positive and negative outcomes.

Achievement Level and Gender Differences

The eight response categories for Question 16 produced six significant relationships with grade level, but only three with achievement level and none with gender. The achievement level differences indicated that the higher achievers were more likely than the lower achievers to talk about the new highway resulting in more traffic or accidents as well as more construction of houses or other buildings. Overall, the higher achievers were more likely to mention both positive and negative outcomes, and their responses to this question were generally more sophisticated than those of the lower achievers.

Relationships Among Response Categories

Students who said that a highway would bring more noise to a small town were more likely than other students to also mention the highway bringing more traffic or other negative outcomes, as well as to talk about some of the negatives in train travel when responding to

Question 15 (hassle, crowding, slow because of all the stops). Surprisingly, however, these students were no more likely than other students to talk about the trains making noise.

Students who said that the highway would allow people to get to other places faster or more easily were more likely than other students to have said that the wheel was an important invention because it allowed people to move things more easily and that trucks allowed farmers to get things to market more easily.

Students who said that the highway would bring more traffic and accidents to the town were more likely than other students to have said that transportation made the world smaller because transportation-related construction took up a lot of space. These students appeared to value small town and rural settings over congested urban settings. Finally, the more sophisticated responses to Question 16 tended to correlate with the maturity set for the interview as a whole.

Rare and Unique Responses

The students saw more negatives than positives, and the positives tended to be limited to the responses coded for the ideas that the highway would make it easier for people to travel to other places or that it would stimulate more construction of houses and other buildings. No student mentioned improvement of the economy (more business for stores, more stores built, more jobs, etc.).

Many of the students who were coded in Category 4 (the highway would create more or more dangerous traffic or more accidents) spoke about the difficulty of safely exiting your own driveway if the highway was built right in front of your house.

Kindergarten: You would have to walk under bridges and snow could fall on you.

First grade: None.

Second grade: More dust; you could go up on the highway for a vista view of your house; there would be more people driving through the town (described this as a good thing but could not explain); it would be better for other people but not for you, because traffic on the highway would make a lot of noise and the highway looming over your house would cause you to get less sunshine.

The following second grader is coded for a particularly good response: "There would be a lot more cars coming through. It would be busy. People would be shopping and stuff. There probably would be more houses being built around here. (In what way would it be better?) You could get to a lot of places easier or faster. (In what way would it be worse?) If they built it right in your backyard, you wouldn't have as much backyard."

The following second grader is quoted for an unusually negative statement: "The town would be different because when there's a highway, there's usually a city around it. If it came right through here, it would ruin that. It's like the people who build roads are kind of mean because they take down nice little trees and stuff just to build one little city highway. (How might the town be better if it had a highway through it?) It wouldn't be better. (And how would it be worse?) There would be more cars driving through and more pollution in the air. A lot of

houses and churches would probably be knocked down. I live in a small town and if a highway went through my town, I would be really mad because it's a nice quiet town."

Third grade: There would be less room because highways and cars take up space; it would be hot and sticky near the highway; it would smell bad; the highway would make it harder for you to get to a friend's house who lived nearby but on the other side of the highway (two other third graders made similar "barriers to local travel" responses); it would smell bad; there would be air pollution (2).

Discussion

Even though this was a relatively "macro" question, the students again responded mostly at the micro-level, talking about how the highway would affect individuals (making it harder for them to get out of their driveways, creating irritating noise or pollution, allowing them to get out of town more quickly, etc.) rather than talking about how the highway would change the town as a whole. The students were much more aware of potential negative effects on the town than potential positive effects. Except for a few references to construction of more houses and other buildings (not always viewed as positive), the students seemed unaware of the effect of a highway in stimulating the local economy. Older students were notably better than younger students in responding to this question, but there were no achievement level or gender differences.

Transportation and Farming

The next two questions addressed students' awareness of how innovations in transportation have affected farmers and access to farm products. Question 17 asked about how the use of trucks changed the nature of farming. We wondered if students would realize that trucks not only made it easier for farmers to get their crops to market but made it possible for them to run much larger farms because large crop yields could be brought to market quickly. Question 18 asked about why apples are available in Michigan in the winter. It was designed to assess the degree to which students were aware of the role of modern transportation systems in bringing fresh produce to our tables all year long.

Question 17. A long time ago, farmers didn't have trucks. Then they got trucks. How did the farming business change after trucks were built? . . . How did trucks make things different for farmers? (If necessary, **What difference would it make if farmers could take produce to market in trucks?)**

Question 18. Apples grow here in the summer, but not in the winter. But even in winter, we can buy apples. Why is that? (If necessary, **So you think that the apples in Meijer's were grown here in Michigan and then frozen?)**

One third (32) of the students were unable to respond to the question about how trucks affected farming. The remaining students said that farmers could use the trucks to take farm products to markets (33), that they could use the trucks to do work on the farm (22), that trucks allowed them to get places faster (14), or that they no longer needed to walk or carry things by

hand (14). These responses were all sensible as far as they went, but none of them included anything about trucks increasing the size or scope of farming operations.

Responses to Question 18 conveyed very little awareness of the role of transportation in bringing fresh farm products to our tables all year round. Only 15 students talked about apples being imported from other states or countries when they are not available locally. The remaining students either could not respond to the question at all (20), failed to address it directly by talking only about the processes involved in getting apples from the trees to the stores in the summer and fall (9), or thought that the apples sold in local stores in the winter were grown locally—picked in the summer and preserved for sale in the winter (52). Some of the latter students talked about chilling the apples or taking other steps to preserve them, so they at least were aware that apples eventually rot. Nevertheless, even these students were under the impression that the apples bought in local stores in the winter had been grown locally and preserved, not imported from elsewhere. The following examples from average-achieving boys and girls are representative of the responses from students across the four grade levels.

Kindergarten

Jered

17. Cause they had wheels and pedals . . . not pedals. Let me think . . . I forget.

18. Because you could go to a store and buy some apples. (Where does the store get the apples from?) From these boxes. They're inside these boxes. They'll open the boxes and reach a couple and put them inside the bag. (But where do Meijer's get the apples from in the winter?) Apple trees. The apples could fall off. (So you think the apples in Meijer's were grown here in Michigan?) Yeah.

Kate

17. I don't know.

18. Because people have apples in their yard that fall down to the ground and they pick it up and they take it to the store. (Yes, but that happens in the summer or in the fall, but now it's winter and yet we can still buy apples at Meijer's. Why is that?) Because . . . I don't know. This is hard.

First Grade

Chris

17. Because they could take the hay or the stuff they needed to feed the other people and feed the cows and pigs and stuff. (Yeah, so they could use it for feeding the animals and things. Well, what difference would it make if farmers could take the produce to market?) They could drive there except they might run out of gas.

18. Because in the winter they can't grow because if you took one off and you bit it, it would be like so hard your teeth would fall in there. (But they pick all their apples in the fall anyway, right? So why is it that we can get fresh apples in the winter?) Because it's too cold for them to grow. (Yeah, but we can go to the shops and they're there.) Because they have these special things and they have because my dad used to work at Meijer's and I went there and they had this special kind of garden and they put some seeds in the tree and had apples on them and they picked it and they checked if they had any worms in them or something and then they washed them. (So how can we get apples in Meijer's in winter?) Because it's hot in the special garden and they keep the right temperature.

Lauren

17. They could get corn from the stores instead of just planting corn all the time and they could get milk from the stores. (OK, how do trucks make things different for farmers?) Well, they could get places faster. (OK. What did the farmers do before they had trucks?) They planted things and they got milk from cows. (Now the farmers would grow the crops, is that right? OK, so how would the farmers get the crops to the stores?) Well, they could walk to stores and they could put them in the back. (OK, so how did things change after farmers got trucks?) They could get the food faster to the stores.

18. Because the farmers grow lots of apples and the apple trees grow lots of apples and they bring them to stores, the people who find them sometimes bring them to the stores and they get lots of apples and then they grow again on the trees. (Any ideas about why we can buy apples here in the wintertime even if they only grow in the summer here in Michigan?) No.

Second Grade

Mark

17. That the farmers, they didn't have to like drive their stuff there and the truck could just come and get it, and they could just drive it to the store. (OK. How did trucks make things different for farmers?) They could get more food off there. So then like, it wouldn't get all bad just sitting on the ground. (OK. How did farmers get their produce to the market before there were trucks?) They would drive it there. (How about before they could drive it there?) They can walk. (So what difference would it make to the farmers if they could take their produce to market in trucks?) It would be easier for them, and they could just like get more food done, so it wouldn't take them a long time. (Why else would it be easier?) So then they wouldn't have to waste like half of their food.

18. Because in some other places, like Florida, they have apples there. Then they just ship some of them down there. (OK. Why do they have apples in Florida?) Because it isn't always cold.

Emily

17. Because then the farmers could get in the truck and go somewhere where they had hay and they could pick hay from there and put it in the truck and then they could drive back to their farm. (What difference would it make if farmers could take the things they produce to market in trucks?) Because if they had too much hay, then they might wrap some up in another bag and take it to the store so other farmers could come and get hay.

18. Because before winter comes if it's getting cold, and there's still apples on your trees, you can go outside and pick them. (But I can buy apples now in the shops. Why is that?) Because the shops might get apples from people and they might take it to the store and sometimes schools might have some apples and they might take it to the food bank, and then the food bank might give some of the apples to the market. (The apples I get at the shop, are they the ones that were grown in the summer in Michigan? Are they the same apples or different ones?) They might be different because there's green apples, yellow apples, and red apples, and the green ones taste a little bit more sour than the red apples do. (So the apples I can buy at Meijer's—where did they come from?) They might come from trees in the summer, they might come from other people's homes, they might come from soft, soft grass on the ground.

Third Grade

Dale

17. They could carry stuff with the trucks to all the places that they needed because they're going to grow stuff for them, but first they're going to grow stuff and bring stuff to the stores and then they'll get some money and then they can buy food, or they're going to make food and save that for storing and buying food and eat that. (What difference would it make if farmers could take produce to market in trucks?) It'd be better because they wouldn't have to walk so far.

18. Oh, they save their apples in the store because they pick them earlier and then they bring them to the store. (So you think that all of the apples at Meijer's were grown here in Michigan and then stored?) Yeah. They grab them earlier and then when it starts to get snowy, they'll have to get it.

Chelsea

17. There's cars and trucks right now to deliver the food to the markets and the markets sell them, and the farmers just help and sometimes they get money for it, and if there were no trucks today, then the market would have to go to the farmer and get it by hand.

18. Cause you can go to the store and in the summer you can just pick it off from an apple tree instead of going to the store because the store charges money for the apples, and sometimes when the apple tree is right in your yard, then you don't have to pay for it. (You said we can get them from stores. Where do the stores get their apples from?)

Sometimes from farmers' apple trees but sometimes from other markets if they need it. (So do the apples that we eat now—do they come from Michigan or do they come from somewhere else?) Probably Michigan but sometimes they can come from somewhere else because you can export them. If my grandpa exported some oranges to us in our area, like they brung it but sometimes they could have just mailed it or they could put it on a truck and export it to Michigan and give it to us.

Grade Level Differences

Younger students were more likely to be unable to respond to Question 17, whereas older students were more likely to say that trucks allowed farmers to take things to market, to get places faster, or to ride instead of walking or carry things on the truck instead of by hand. Concerning Question 18, younger students were more likely to be unable to respond or to fail to address the question because they only talked about the process of getting apples from trees to stores in the summer. In contrast, older students were more likely to talk about importing apples from other states or countries or about preserving locally grown apples for sale in the winter. Note that the latter response was positively associated with grade level, even though it is a misconception.

Achievement Level and Gender Differences

The nine categories for responses to Questions 17 and 18 yielded eight significant relationships with grade level but only one with achievement level and none with gender. The achievement level difference indicated that more higher achievers than lower achievers said that farmers could use trucks to take things to markets. This was generally the most sophisticated of the popular responses.

Relationships Among Response Categories

The only noteworthy correlations involving categories for responses to Questions 17 and 18 were positive relationships between sophisticated response categories and the maturity set for the interview as a whole. These were particularly noteworthy for responses to Question 17 indicating that farmers could use the trucks to take things to market and responses to Question 18 indicating that apples are imported from other states or countries.

Rare and Unique Responses

Several students started to answer Question 17 with reference to tractors rather than trucks, so the question had to be clarified for them. Most of what the students said was well captured by the categories, although there were a few unusual responses.

Question 17

Kindergarten: None.

First grade: After trucks, farmers could drive to the store and buy food instead of having to grow it (presumably this student meant that the farmers could now buy some of their food instead of having to grow all of their food); after trucks, if farmers wanted to go someplace and not have their cow get sick or something, they could put the cow in the back of the truck and take it with them.

Second grade: Farmers could now buy food at stores; store employees could use the trucks to come to farms and pick up produce/milk, so the farmers wouldn't have to interrupt their work to take it to the store; the roads built for the trucks would reduce the available farm land.

Third grade: Food could now be transported to other states.

Question 18

Some of the younger students had difficulty understanding the point of the question because they thought that stores would just keep getting apples as needed from farmers (not realizing that apples are only available in season). In addition, several students expressed some variation on the idea that apples will be good indefinitely if you pick them at the right time, but if you wait too long, they will spoil or freeze.

Kindergarten: They would grow apples in indoor gardens (greenhouses?).

First grade: Special heated gardens kept at the right temperature are used to grow the apples in the winter.

Second grade: None.

Third grade: Greenhouses are used to preserve picked apples (as opposed to being places to grow them); the apples are kept indoors and kept warm to preserve them until they are needed; some types of apples grow in the winter.

Discussion

Responses to Question 17 once again focused on the micro-level, with students talking about how individual farmers might use their trucks but not about how trucks transformed the nature and scope of farming as a business.

Responses to Question 18 indicated not only that most students were unaware of the role of modern transportation in bringing fresh farm products to our tables year round, but also that this lack of awareness was associated with a more fundamental lack of awareness that the farm products sold in stores during the winter have been transported from other states or nations. Even though we asked about a food (apples) that is familiar to the students, is grown locally and harvested in the summer and fall, and does not undergo significant processing or transformations in appearance between being picked from the tree and bought in the store, a majority of the students harbored the misconception that apples bought locally in the winter were grown locally, picked in the summer or fall, and then preserved for sale in the winter. Furthermore, this

misconception was positively associated with grade level, observed in two-thirds of the second- and third-graders. Thus, the students not only were not very aware of the role of transportation in bringing farm products from other states or nations to our local stores, but unaware that harvested fruits and vegetables cannot be stored indefinitely until needed (without processing beyond merely heating or cooling them). Thus, here is an instance where lack of knowledge relating to one cultural universal (food—specifically, knowledge that harvested fruits and vegetables must be preserved if not eaten while ripe) contributed to lack of knowledge about another cultural universal (transportation—specifically, the role of modern transportation systems in bringing fresh fruits and vegetables to our local stores all year round).

The grade level differences in responses to Questions 17 and 18 were not surprising in that the older students were more able than the younger students to provide substantive responses to these questions. However, even some of the relatively low-level responses showed positive relationships with grade level. These included responses to Question 17 that focused on how trucks made the general lives of farmers easier (they could get places faster, they didn't have to walk as much, they didn't have to carry things by hand) rather than addressing how trucks changed farming as a business, as well as the response to Question 18 indicating that local apples are picked in the summer and then preserved for sale in the winter. These positive relationships with grade level reflect the fact that these two questions were particularly difficult for the students. Most of the kindergarten students could not provide substantive responses to them at all. The older students were generally able to respond, but frequently with responses that failed to address the question fully (for Question 17) or reflected good reasoning but were based on invalid assumptions (for Question 18).

Urban Transportation

The next two questions focused on forms of transportation found particularly in big cities. Question 19 began with an open question about what kinds of transportation are found in big cities but not in other places, intended to assess students' awareness of buses, subways, taxis, and other forms of transportation found primarily if not exclusively in cities. A follow-up question asked why people in cities use buses or subways instead of cars, to see if students were aware of the fact that many people in cities do not own cars or do not use them in the cities because of traffic congestion, the scarcity and cost of parking, and so on. Question 20 focused on taxi cabs, initially asking students what they are, then why people use them, and finally how the fare is determined. Our previous interview on shelter included questions on highrise apartment living in cities, and the students' responses revealed that many of them were unfamiliar with large cities. Consequently, we expected similar unfamiliarity to show itself here.

Question 19A. What kinds of transportation do you find in big cities but not in other places?

Question 19B. Why do a lot of people in big cities use buses or subways instead of cars?

Question 20A. What is a taxi cab?

Question 20B. Why do people use taxi cabs? . . . Do they have to pay to use taxi cabs?

Question 20C. How does that work? . . . How does the taxi driver decide how much you should pay?

A total of 38 students were unable to respond to Question 19A asking about kinds of transportation found in big cities but not in other places. This was many more than expected. Furthermore, the most popular response among students who did answer was cars, an incorrect response made by 36 students. Another 14 students incorrectly said trucks or vans. More correct responses included trains (24), buses (23), planes (16), and taxis (13). Finally, 14 students named other forms of transportation such as boats, bikes, or limousines.

When asked why people use buses or subways instead of cars in cities, again 38 students were unable to respond. The remaining students suggested that the people do not have cars (20), that buses and subways can go faster than cars (20), that the people take subways because traffic and stoplights impede surface travel (11), or that it is simply easier to travel on buses or subways, because you do not have to drive yourself (9). In addition, 20 students made other responses (buses and subways are bigger, they have room for more people, etc.).

The students were better able to answer Question 20. All but 12 of them were able to say something about taxi cabs, and what they did say was correct. Majorities of the students defined taxis as cars that take people where they want to go (58) and/or described them as yellow or checkered cars with a taxi sign on the top, a number on the back, etc. (52). Other responses included the idea that a taxi is a car that someone drives for you (25), a car that you pay to use (24), or a car that will stop and pick you up if you signal it by waving or whistling (13).

All but 10 of the students also were able to respond to Question 20B asking why people use taxis. More than half (46) of those who responded said that people use taxis when they don't have a car to use, and most of the others (37) were less explicit about lack of access to a car but did show understanding of taxis as auto transportation that people use for local travel. Finally, 7 students said that using a taxi is cheaper than buying or renting a car. Taking into account everything that the students said in responding to the various parts of Question 20, we determined that a significant majority (81) of them displayed understanding of taxis as local transportation that people pay for when they are not driving their own cars (or do not own cars).

Question 20C asked whether people have to pay to use taxis, and if so, how their fares are determined. Almost half (45) of the students understood that people do have to pay and that the fare is determined by the distance traveled. The remaining responses were spread across several categories that varied in accuracy: 12 students did not know whether or not people have to pay or said that they do not have to pay to use taxis, 18 knew that people have to pay but could not explain how the fare is determined or simply guessed a dollar amount without explanation, 11 said that they pay what it says on the meter (but did not explain how the meter arrives at the number), 6 said that the cost of the ride is determined by the number of people in the taxi or the number of stops that it makes, 14 said that the cost is determined by the time required for the trip, and 7 said that the fare is determined by the driver's boss (without further explanation). The following examples from average-achieving boys and girls are representative of responses from students across the four grade levels.

Kindergarten

Jered

19A. A car. (What sorts of transportation do you find in the city that you don't find in other places?) A plane . . . and trains.

19B. I don't know.

20A. I don't know.

20B. To get to other places. (But what is a taxi?) It's a yellow car and has black and white squares on it and you can get to one place from the other.

20C. I think so. (How does that work—how does the driver decide how much you should pay?) I don't know. One dollar or something, or two dollars, or a hundred dollars. (How does he decide?) He has a brain to think with, and . . . I forget.

Kate

19A, B. I don't know.

20A. A taxi cab? It's a car that picks other people up.

20B. So they could ride on it.

20C. Yeah. (How does that work—how does the driver decide how much you should pay?) One dollar. (How does he decide that?) He could look on the sign.

First Grade

Chris

19A. I don't know.

19B. Because probably they didn't have cars and they had a little money and they could just drop it in when they're on the subway or the train.

20A A car.

20B. Because probably they're old and they don't have that much money and if it says you have to pay one dollar, and they only had four quarters, they gave them to them and then he would take them someplace and they could drop off and they'd rest.

20C. Yes. (How does that work? How does the driver decide how much you should pay?) Because they say "I want to go to Michigan" and that's a short drive. They said it

would say you have to take one dollar or two or something. (But how do they know it's one dollar or two dollars or five dollars or ten dollars?) Because they knew how short their drive was because they've been in there for a very long time.

Lauren

19A. You find lots of cars.

19B. I don't know.

20A. It's a car—a certain car who helps people without cars get to other places.

20B. Because they don't have cars.

20C. Yeah. (OK. So if they have to pay, how does that work—how does the driver decide how much you should pay?) I don't know.

Second Grade

Mark

19A. (No response)

19B. So they can get places faster. (Why do you think you can get places faster on a subway or a bus in the city than you could in a car?) Because with cars you have to wait and then trains are just like free, and they can keep on going without stopping.

20A. (No response)

20B. To get around to places if they didn't have a car. (What makes a taxi different than a regular car?) They have like TVs in them. (OK, can you imagine any times when a person might need to use a taxi and they have their own car?) No.

20C. Yeah. (How does that work?) Like as soon as they get dropped off, you have to pay them because it would be just a waste just to like sit there. (Who do you pay?) The driver. (And how does the driver decide how much you should pay?) How far you go.

Emily

19A. They might use trains, because a lot of people I know don't use trains to go anywhere—they use cars. If their cars run out of gas when they get home, they might use their neighbor's car if they're not going anywhere and then they can drive them to a train and they can ride on the train.

19B. I don't know.

20A. It's a car that if someone might be sick and their mom was close by, then they'd call the taxi and the taxi might take them to the school.

20B. Because their car might run out of gas and they might call a taxi to come and they might go to the taxi..

20C. I don't know.

Third Grade

Dale

19A. In big cities you usually find taxis. Sometimes you can find taxis in Michigan.

19B. Because it's fancier, but if they have a clean car or truck then they don't have to worry. And you get food on them maybe, sometimes. (What do you mean?) Like sometimes on an airplane they serve you, and maybe on a subway, but I don't know.

20A. A taxi cab carries you to places. They say, "What place you want to go?" and you go to that place and then you have to pay them.

20B. So they can get around, because if they don't have a car, then they're going to have to use taxis and pay.

20C. He maybe has a thing for each mile you go and it keeps on rolling and rolling.

Chelsea

19A. Sometimes there's more airports than there is in little neighborhoods. Sometimes you can't find trains in little places and most of the time you can find railroad tracks that have trains on it. Like if you come from the airport or the hospital you can go past a railroad track and a train.

19B. Because if they don't have enough money, then instead of just renting a car, they just get on a subway or bus and they only charge you like a dollar or something instead of getting gas and stuff for the car.

20A. A taxi cab . . . sometimes there can be people that are in wheel chairs but sometimes not, and taxi cabs are like a bus but a different color. (Are taxis the same thing or are they different?) A taxi is just a car but it has a taxi sign on top of it and it's yellow.

20B. Because sometimes if they don't have a car and the bus doesn't go in their area, then they can just go yell "Taxi," and the taxi can stop and then they can give the taxi money and it's easier in little places where the taxis are, and sometimes it's harder, and sometimes you can't find buses right by your house.

20C. If it's a really long way, then sometimes . . . like from Michigan to up north they have to pay like maybe . . . well, it depends on the hours and the minutes and the half hours to get there. Like if it takes two hours, then they would probably charge like $20.00 or maybe more, and sometimes if it's like a little way, not even a half an hour—like 20 minutes, then they only charge like $5.00.

Grade Level Differences

Younger students were more likely to be unable to provide substantive responses to these questions, and older students were more likely to provide the more sophisticated responses. However, along with identifying buses, trains, taxis, and planes as forms of transportation found in big cities but not in other places, older students also were more likely to mention cars. Otherwise, older students were more likely to say that people use buses or subways because they don't have cars, because it is easier/you don't have to drive, or because subways avoid the traffic and stoplights of surface travel. They also were more likely to describe taxis and to define them as cars that you pay to use, to demonstrate understanding of taxis as local transportation that you pay for when not driving your own car, and to know that the fare is determined by the length of the ride. The remaining responses, which failed to show significant relationships with grade level, tended to be low-level or incorrect answers. It was surprising, however, that none of the categories for substantive responses to Question 20B (about why people use taxis) was correlated with grade level.

Achievement Level and Gender Differences

The 32 categories for responses to Questions 19 and 20 yielded 18 significant relationships with grade level but only 6 with achievement level and 4 with gender. One of the relationships with achievement level was nonlinear, indicating that average achievers were less likely than other students to mention buses as forms of transportation found in cities. The other five relationships were linear ones indicating that high achievers were more likely than low achievers to mention trains and planes as forms of transportation found in cities, to say that buses and subways go faster than cars or to give "other" reasons why people use them, and to describe a taxi in terms of its physical appearance. These differences suggest a general but limited tendency for the higher achievers to make more sophisticated responses to Questions 19 and 20 than the lower achievers did.

One of the gender differences appeared because 10 boys but only 4 girls named trucks or vans as forms of transportation found in big cities but not in other places. The other differences concerned reasons why people use taxis. Boys were more likely to give vague or questionable reasons for why people use taxis, whereas girls were more likely to say that these people do not have a car of their own available at the moment. These four significant differences favored girls, although inspection of the complete set of responses to Questions 19 and 20 does not suggest a clear gender difference in knowledge about urban transportation.

Relationships Among Response Categories

Students who mentioned cars as kinds of transportation found in big cities but not elsewhere were more likely than other students also to mention trucks or vans. Both of these responses would be considered incorrect, given the wording of the question. Recall, however, that the "cars" response was positively associated with grade level.

Students who mentioned trains in response to Question 19A were more likely than other students also to mention planes. More generally, there was a loose tendency for students who mentioned any of the substantive response categories for Question 19A to also mention one or more of the others. This pattern is to be expected when 38 students are unable to respond to the question but the other students provided an average of almost 2.5 responses each.

Students who mentioned planes in response to Question 19A were more likely than other students to have mentioned planes in responding to Question 3C (about forms of transportation we use now that people long ago didn't have) and Question 11 (asking why it is easier for us to cross mountains today than in the past). Thus, these students had a greater consciousness of airplanes than other students did. Otherwise, notable intercorrelations involving these categories were restricted to relationships between categories for sophisticated responses to Questions 19 and 20 and categories from the maturity set for the interview as a whole.

Rare and Unique Responses

Question 19A

Kindergarten: Boats, jet skis; subways, trolleys; boats; horses (most if not all horse responses referred to the horse and carriage services that cities provide for tourists, and thus are not as inappropriate as they seem at first).

First grade: Carts pulled by horses; boats; horses.

Second grade: Wagons and tractors, subways; boats, dune buggies; horses, bikes; monorails.

Third grade: Trolleys; bikes, subways; boats; subways; limousines; boats, bicycles.

Question 19B

Some of the unusual responses make more sense for subways than for buses (e.g., the idea that they are a faster or more convenient way to travel in cities). Along with the responses listed below, four students said that people use buses or subways so that they do not have to pay for gas for their own cars.

Kindergarten: These forms of travel don't cost much.

First grade: Their car might be in the repair shop.

Second grade: For some people, the bus or subway goes just where they need to go, like near their jobs; they go to places where you haven't been to; cars have speed limits but subways

don't because there's no other subways coming their same way; many city people don't have cars because they are afraid the cars will be stolen; they are afraid they might get into an accident if they drive; trains are faster because they are powered by electricity that comes in at 2,000 volts per minute; your car might be in the repair shop; people who use them just got to the city and don't have a car yet (parallel to responses to our shelter interview indicating that people who live in apartments are people who just got to the city and don't have a home yet); they don't want to pollute; the city streets are too crowded to accommodate cars for everyone.

Third grade: There are lots of buses and taxis in the city so you don't need a car; city people cannot afford cars because they buy so much from all the stores; maybe the subways are fancier—maybe they serve food on them, like on planes; because you can't park your car in a big city; because the subways are free; because they make less pollution.

Question 20A

Everything said in response to this question (What is a taxi cab?) is covered in the coding categories.

Question 20B

Kindergarten: Taxis are a way to get home if you forgot where you left your car; they put in their luggage and go to a hotel (i.e., people who have just arrived in town).

First grade: Old people like taxis because you can just rest and be driven around; you can avoid driving in urban traffic where it is hard to even get out of your driveway; you use a taxi when you don't know how to get there on your own.

Second grade: Use a taxi when your car is too small for the group that will be traveling together; use a taxi if the buses are full.

Third grade: Use a taxi because you don't get squished like on buses; used by people who live in areas not served by buses; taxis are faster because taxi drivers don't get tickets for speeding.

Question 20C

Responses to this question about how taxi fares are determined are all covered in the response categories except for those of one first grader who thought that all riders pay the same amount (flat fee), one second grader who said that you have to pay more if the taxi looks like a limousine, and one third grader who said that the cost of the ride depends on how much gas is required.

Discussion

The students' responses to Question 19 were surprisingly poor. When asked about forms of transportation found in big cities but not in other places, 40% were unable to respond and

more than half of the rest mentioned cars, trucks, or vans. Apparently, the qualification at the end of the question ("but not in other places") didn't register with most of the latter students. This interpretation seems more likely than the alternative interpretation that the students actually believed that cars are found only in cities but not in other places, especially because this response was correlated positively with grade level. When asked the follow-up question about why people in cities use buses or subways, most of the students able to respond gave knowledgeable answers emphasizing that these people may not have cars or that the public transportation may be cheaper, easier, faster, or more convenient for them than driving/parking in a congested inner city.

A heavy majority of the students understood that taxis are cars hired for local transportation by people who do not have a car available at the time. Younger students mostly were unable to say or could only guess about the fare, but older students often knew that the cost is determined by the length of the trip. Higher achievers tended to supply more sophisticated responses than lower achievers, although these differences were much smaller than those associated with grade level. There were a few gender differences but no overall pattern indicating that one gender knew more than the other about urban transportation.

Although a few students made reference to crowding and hassle involved in train travel when responding to Question 15, the responses to Question 19 typically depicted bus and subway riding in a positive light. That is, students suggested that city people might prefer to ride buses or subways instead of driving because someone else could do the driving for them, it might be a quick and convenient way to get to work or school, and in the case of subways, a way to avoid traffic and stop lights on the surface. No student mentioned crowding, having to wait, or having to walk to and from the bus stop or subway station. However, a couple of answers to Question 20 noted that people might want to use a taxi if buses were full or would prefer taxis because "you don't get squished like on buses." The rare and unique responses concerning urban transportation tended to be accurate or at least defensible, including one third grader's observation that taxis are faster because taxi drivers don't get tickets for speeding.

How Cars Work

Question 21 addressed students' knowledge about how cars work. We were particularly interested to see if the students knew anything about the workings of the internal combustion engine, so probing focused on this with students who mentioned the engine.

Question 21. How does a car work—what makes it go?

All but three of the students made some initial response to this question, typically by naming one or more car parts. Heavy majorities mentioned the motor or engine (74) and oil or gasoline (62). In addition, 32 students mentioned the wheels, 27 the pedals, 17 the steering wheel, 6 the battery, and 22 miscellaneous "other" parts such as wires. These initial responses were noted but the students then were probed to see if they could provide an explanation for what makes the car go. Their responses to this probing for explanations are shown in Table 1.

Once again, 40% of the students were unable to respond. However, the remaining students provided responses that were generally accurate as far as they went in identifying steps or processes involved in "making a car go:" 15 spoke of starting the car with a key, 17 mentioned pushing on the gas pedal, 25 said that the engine makes the wheels turn, 27 said that gasoline is needed, and 15 made miscellaneous other observations such as that wires from the engine make the car go, the battery gives power to the engine, or piston motion in the engine is transferred to the wheels. The engine was a black box for the vast majority of the students, even those who mentioned it spontaneously, so their responses to this question focused more on what the driver does to make the car go (start it with a key, give it gas, etc.) than on the functioning of the engine or other mechanical parts that "make the car go."

Individual students mentioned quite a number of car parts beyond those in the basic categories: drive shaft (described without giving the name), gear shift/shift lever (several mentions), tail pipe, gears, radiator, disk brakes, generator, starter, and a few others. However, these terms often were used in ways that showed that the student did not understand their meanings or functions. No student gave a clear explanation subsuming the key elements that gasoline(mixed with air) is burned within the cylinders to create explosions that move the pistons, and this piston movement in the engine results in a turning of the axle that makes the car's wheels move. Three students supplied partial explanations that talked about piston movement in the engine resulting in movement of the wheels and thus the car (although without necessarily using these terms), but none of them mentioned burning of gasoline or explosions that get the pistons moving.

Responses to Question 21 often were less sophisticated than the category labels imply. For example, students who spoke of "pushing down the pedal to make the car go" were coded in Category 3, even though they may not have mentioned the engine and may not have known what happens when the driver pushes on the pedal (i.e., that this is a gas pedal and depressing it feeds more gas to the engine).

Several students emphasized the role of gasoline in their responses. Some of them talked about gas starting out in the gas tank, then traveling throughout the car, and eventually coming out the exhaust in gaseous rather than liquid form. These details notwithstanding, many of the students who made these responses did not understand the role of gasoline in fueling the engine (i.e., did not understand that it is burned to create explosions, etc.). The following examples from average-achieving boys and girls are representative of the responses from the students across the four grade levels.

Kindergarten

Jered

21. The motor and the pedals and the brake, and I forget what else. (How does the motor work?) You put in the keys and twist the keys this way and then the motor goes. (How does it make the car move?) Because of the motor and the wheels and the brake.

Kate

21. Push the pedal. (What does that do?) It makes the car move. (How does it make the car move?) Because it just moves because you push the pedal. (Is there anything else that makes the car move?) The engine. (What does the engine do?) It makes the car start—and the keys. That's all . . . and the motor. That's all.

First Grade

Chris

21. The wheels and the pedals, and the motor helps it—like connects to the thing and it goes round right here and it connects right here. Then you step on the pedal and the wheel—the back wheels—move. (Probably those move too?) Yeah, and these ones turn, but these ones don't move because these have the . . . (The front wheels have what?) The turning thing. The wheel's connected to the steering wheel, and the steering wheel's connected to this. (To the front wheels?) Yeah, and you can turn but these don't move and this . . . they just roll. (The back wheels just roll?) Yeah, they move the car and the front wheels are connected to the steering wheel and these turn, but these ones don't move, they just roll to get to the other places and stuff. (What makes the back wheels move?) The motor. (How does that work?) I don't know. (That's a great explanation. Is there anything else that makes a car work—that makes a car go?) I think it is the exhaust because when you step on the pedal, the exhaust comes out. And it takes like gas in it and it'll ssssshhhh. Yeah, so it won't like go like if you turn the air conditioner on. It doesn't go swwwoooo right in there. And the exhaust takes the gas from this and it goes ffffssss out of the back. (Out of the tail pipe?) Yeah.

Lauren

21. The wheels. (How does the car make the wheels turn? Is there something in the car that makes the wheels go?) I don't know.

Second Grade

Mark

21. I don't know.

Emily

21. The engine. (How does the engine make the car go?) I don't know.

Third Grade

Dale

21. I think it would be the engine because that would make it go real fast, and the radiator would make it go faster, and if they don't have a wheel, it won't turn or nothing. (How does the engine make the car move?) An engine will make it go faster and makes it move. (Yes, but how does it do that?) The oil in it starts up and starts going. It's hooked up to the wheels probably. Yeah, it's hooked up to this thing called disk brakes and that makes the wheels go.

Chelsea

21. A car works from the engine and the steering wheel helps the wheels move and then you can turn or go straight and go backwards by the shifting. (What is it about the engine that makes the car go?) The engine makes the car go because . . . first of all you have to have gas to have it go and the gas is like what makes the engine go and the engine could make the car go, and then the steering wheel and the shift could move it and go backwards and go forwards.

Grade Level Differences

Younger students were more likely to be unable to respond to this question and older students more likely to mention pushing the gas pedal, the role of the engine in making the wheels turn, the need for gasoline, or "other" factors. Only the mention of using a key to start the car was unrelated to grade level.

Achievement Level and Gender Differences

Although five of the six categories for responses to Question 21 showed significant relationships with grade level, there were no significant relationships with achievement level and only one with gender. The gender difference indicated that 16 boys but only 9 girls said that the engine makes the wheels turn. Furthermore, nonsignificant trends involving most of the other categories suggest that the boys were more able than the girls to respond to this question. This difference might have been expected based on gender differences in socialization and interests. However, it should be kept in mind that only one of the categories showed a statistically significant gender difference and that most of the explanations offered by children of either gender were limited in scope or included misconceptions.

Relationships Among Response Categories

Noteworthy intercorrelations involving categories for responses to Question 21 were limited to correlations between the more sophisticated responses and the maturity set for the interview as a whole.

Rare and Unique Responses

Kindergarten: The engine makes "like air" in the wheels and they spin; gas travels to all parts of the car and makes them go; gas goes "somewhere" in the car to make it go; the cars burns gas and "once it's burned up, there's enough fuel and it's ready to go."

First grade: The engine, which has plugs everywhere, gives power to the car, and then the car gives it to the driver's steering wheel and the car goes; the exhaust is involved because when you step on the gas pedal, "the exhaust comes out."

One first grader provided one of the best responses: "The gas. There is like the lighter [starter or spark plug?]. There is something that goes down and lights and makes the fire go down and heats up the motor's propeller blades inside the motor [airplane analogy], so it could go around and make the . . . and the motor controls the wheels. So if that thing goes around, it's telling the wheels to turn around too."

Second grade: The gas has "this lightning power" that makes the car move; the engine "sends a force" and the wheels go; the engine "blows air" or does something else to make the wheels go (analogy to a jet engine).

The following second grader is quoted for one of the better responses: "An engine. (And how does the engine work?) You need gas to power it, and it has all these little parts [pistons] in it that go up and down in a cylinder. The cylinder is round, with a flat top. It's inside the engine. The axles make the wheels go around, and the steering wheel has a little bar that goes down to the axle and turns it. (So how does the car actually move?) It's powered by gas. And a wheel. Sometimes the front wheel, sometimes the back wheel, sometimes all the wheels make it go."

Third grade: There's a cord in the engine that gets pulled to start it (analogy to lawn mower); the gas tank is at the rear of the car so it can get gas to the rear wheels more quickly; the gas starts at one part of the car and then works its way through the other parts to make it go (one of several "traveling gas" responses). In addition, the following third graders are quoted for particularly noteworthy responses.

A good response that contains some unusual elements: "Probably the gas—the gas tank—it goes to the engine. (How does that work?) It probably has some sort of a suction cup that drains the gas out of it. It goes from a tube to the engine. It starts to boil the water in there and the engine warms up and gets going. In old cars, you had to wind it to get it started. Then you pushed the pedal of the car and it will go. (What does the pedal do?) It puts pressure on it. You might push a little lever and push a button and make it go forwards or backwards. Something like that."

An example of a student who uses specialized terms but nevertheless is confused about the workings of the engine: "I think it would be the engine, because that would make it go fast, and the radiator would make it go faster, and if they don't have a wheel, it won't turn or nothing. (How does the engine make the car move?) The oil in it starts up and it starts going. It's hooked

up to the wheels probably. Yeah, and it's hooked up to this little thing called disk brakes and that makes the wheels go."

Another example of vocabulary without understanding: "You press on this thing called a radiator or one of the brakes that make it go, and that will start the radiator in the engine. That goes to the battery and the battery goes to the fuel tank, so the car starts getting shaky and then it starts moving slowly and then it gets faster."

A sketchy but good response: "You push on the gas pedal and it makes the gas go to the engine. (What happens in the engine?) The gas gets burned and then the tires move."

Perhaps the best response: "The motor works by gas which travels from the gas tank into the generator and then the generator gives it to the motor which has motions [makes up and down piston motions with hands]. They move up and down really fast inside the motor, and sometimes it goes out the exhaust pipe with a fire thingy, and that's how the motor works."

Discussion

The students displayed quite a range of knowledge about the workings of automobiles. About 40% could not respond at all beyond referring to gasoline or a few car parts. Most of those who were able to offer some explanation focused on the actions of the driver in starting the car and getting it going, not the workings of the engine. The engine was a black box for most of these students, and most of the rest had confused or erroneous ideas about its workings (including many of those who mentioned several technical terms).

Most students understood that gasoline is needed to run a car, but they were vague about why it is needed or what happens to it once it is in the car. Even those who talked about the gasoline traveling throughout the various parts of the car and eventually coming out the exhaust in gaseous form typically had only black-box theories of the engine or the other workings of the car. Only a few students mentioned that the gas gets burned, and none specifically mentioned explosions that initiate piston movement.

The older students were generally more able to answer this question than the younger students, although one of the three students who provided a good basic explanation of the workings of the engine was a first grader. Most explanations, including most of those that featured reference to specific car parts, were simply incorrect or mixed incorrect elements with correct ones. Most of these were essentially black-box responses that spoke of gas traveling to various parts of the car and these parts somehow becoming activated and making the car go. Occasionally a student articulated a more substantive (but incorrect) theory, such as the third grader who first spoke about boiling water in the engine to heat it up and get it going, but then went on to offer an explanation of the motion of the car that did not involve the workings of the engine but instead indicated that the driver's foot pressure on "the pedal of the car" was magnified through a system of levers to create sufficient pressure on the wheels to begin turning them.

Problems Created by Motor Vehicles

Question 22 was designed to assess students' awareness that, besides facilitating travel, motor vehicles create congestion, noise, pollution, and other problems.

Question 22. It's nice to have cars and trucks, but they create problems too. What are some problems that exist in places where most people drive cars or trucks? (Probe for knowledge of noise, traffic, pollution, etc.) (For students who respond in terms of breakdowns of one's own car, say **OK—that would be for your car. But I was wondering if places where there are a lot of cars have problems because there are so many cars there?)**

Most students were able to identify one or more such problems, although 21 could not respond to the question and another 9 responded only in terms of the problems encountered by individual drivers (running out of gas, blowing a tire, etc.). The most common problem noted was accidents, mentioned by 43 students. Other problems included congestion, delays, and traffic jams (27), pollution in the form of dust, gas/oil spills, or air pollution (18), noise (12), and busy streets that make it difficult for people or animals to cross (8). In addition, a few students mentioned other problems such as a shortage of parking places. The following examples from average-achieving boys and girls are representative of the responses from students across the four grade levels.

Kindergarten

Jered

22. I don't know.

Kate

22. I don't know.

First Grade

Chris

22. Because it's crowded and it goes vrrrooommm, vrrrooommm and they like crash into each other like all the cars crash into each other and it's both their fault because they don't know where they're going.

Lauren

22. They drive them around town and they take people places. (OK, but is there anything that cars do that maybe is not so nice or not so helpful?) I don't know.

Second Grade

Mark

22. They might get in an accident. (OK, anything else that might be a problem?) No. (Well, think about a big highway—lots of cars drive over it and lots of trucks. Would you want your house to be really near that highway . . . ? No? Why wouldn't you want to live near the highway?) Because they would be going fast and if there was a ball out there, they would be going fast and then you could probably get hit. (OK, you could get hit. Why else wouldn't you want to live near the highway?) Because if it's like a dirt road, then al the dirt will fly and then it will like mess up your house—all your windows will be all dusty and stuff.

Emily

22. Last year we drove to Ohio and went to the beach and then when we were getting close to our subdivision, we ran out of gas. (Things happen to people when they're drive in their own car or truck, but what about for the places. I was wondering if places where there are a lot of cars have problems because there's so many cars around?) Yeah, because there's so many cars around and if someone's not watching where they're going, they might bump into another car, and it can happen anyway because you might not be watching or looking for something in your purse.

Third Grade

Dale

22. In traffic you could beep the horn where it hurts somebody's ear, or it crashes. (So there could be crashes and there could be lots of noise. Are there any other problems we have in places where there are lots of cars and trucks?) Yeah, New York has a bunch of cars and trucks and beeping maybe, and maybe somebody goes too fast to get there and it might crash.

Chelsea

22. If there's so many cars then you can't go places really fast because it's like a block where people can hardly even go places because there's so many cars and they go slow instead of fast, like 30 miles per hours. It goes like not even three or five miles an hour and it's really harder.

Grade Level Differences

Younger students were more likely to be unable to respond to this question, whereas older students were more likely to supply several of the substantive responses (accidents, delays/ congestion/traffic jams, pollution, or difficulties in crossing the road). There were no grade-level differences for responses focusing on the problems of individual drivers or for mention of noise.

Achievement Level and Gender Differences

The seven categories for responses to Question 22 yielded five significant relationships with grade level but only one with achievement level and none with gender. Higher achievers were more likely than other students to mention air pollution, dust, or gas/oil spills as problems associated with high concentrations of traffic. Across the remaining categories, however, there was no general tendency for the higher achievers to produce more sophisticated responses than the lower achievers.

Relationships Among Response Categories

Students who mentioned congestion or traffic jams in responding to Question 22 were more likely than other students to also mention accidents in responding to the same question. There also were some parallels between the students' responses to Question 22 and their prior responses to Question 16. However, these linkages were weaker than might have been expected. Students who mentioned traffic or accidents in responding to one of these questions were slightly more likely than other students to also mention the same problems in responding to the other question, and the same was true for mention of noise. The correlation for mention of dust or pollution was positive but did not even reach statistical significance. Otherwise, the only noteworthy intercorrelations involving categories for responses to Question 22 were correlations between sophisticated responses (particularly, mention of noise or pollution) and the maturity set for the interview as a whole.

Rare and Unique Responses

Kindergarten: Broken roads and bridges.

First grade: Cars sometimes stall; you have to put gas in cars and that costs money.

Second grade: Sometimes there are gas shortages and long lines at the gas stations; the engine could catch on fire; road construction reduces space available for other uses.

Third grade: Engine fires; if it is a manual transmission, you could accidentally put it in reverse and blow your transmission.

Discussion

Question 22 proved to be a relatively easy one for the students to address, although more than a fifth of them were unable to respond. The substantive responses were sensible and lacking in misconceptions. Most students were able to name at least one problem associated with a concentration of motor vehicles (accidents, traffic jams, congestion, noise, or pollution). Predictable grade-level differences appeared but there were no achievement-level or gender differences.

Maps

Question 23 assessed the students' understanding of the nature and uses of maps.

Question 23. What is a map? . . . When do people need maps?

The students proved to be quite familiar with maps, at least at the level of their nature and purposes. All but six of them were able to respond to the question. A heavy majority (80) described maps as resources to use when you need information about how to get from one place to another (73 of these students further specified that you would use a map when you didn't know how to find a place, 51 that you would use a map when traveling or going to a faraway place, and 33 that you would use a map when you were lost).

In addition to or instead of describing maps as resources to use when you need to know how to get from one place to another, 35 students described a map as a representation of a geographical area (state, nation, world) or as something that shows you where places are. These responses emphasized physical descriptions of maps, whereas the more common responses emphasized their functions. The following examples from average-achieving boys and girls are representative of the responses from students across the four grade levels.

Kindergarten

Jered

23. A map is a piece of paper and it has kind of like . . . it's a map of the whole world and you can get from one place to the other. (When do people need maps?) Pirates them need. (Why?) Because to get to their treasure. (When are some other times people need maps?) I don't know.

Kate

23. It's a map that you can look at to see where you need to go. (When do people need maps?) When they're lost.

First Grade

Chris

23. To see where you're going. (Yeah. When do people need maps?) When they're driving and they don't know where they're going.

Lauren

23. Well, a map is when you're stuck somewhere, and you don't know where you are, you should get a map out because a map helps people know where they should go. (How

does the map help people know where to go?) They could go like . . . I don't know. (When do people need maps?) When they're stuck someplace.

Second Grade

Mark

23. It's like a map that shows you where to go, how to get places. (When do people need maps?) Like if they're traveling a long ways and they don't really know where to go.

Emily

23. It's this big thing that shows you the states and it might have a park like Yellowstone where there's buffalo when you drive to it and there's this stinky smell of smoke. (When do people need maps?) Because sometimes it can show you where to go if you need to get somewhere and you can't remember which way to go.

Third Grade

Dale

23. It shows you where to go. It shows places, like L.A. and you take your truck and you have to bring a boat too, so you bring a boat, and you get there and walk to a place. Or you could use an airplane. (When do people need maps?) They need them when they don't know where to go usually, because when you get lost you have to have a map. You have to have a map in your pocket so when you get lost you have a map in your pocket.

Chelsea

23. A map is a piece of paper that tells you where you want to go and it's sort of like directions, but sometimes it can't be because there's no house number and stuff or address, so sometimes maps are easier to find people and places.

Grade Level Differences

All six of the students who were unable to respond to the question were kindergarteners or first graders. In contrast, the majority of the students who provided a physical description of maps were second- or third-graders. There was no grade level difference in the most popular response describing maps as something that you use when you need to know how to get from one place to another.

Achievement Level and Gender Differences

Although two of the three categories for responses to Question 23 showed significant relationships with grade level, there were no significant relationships with achievement level or gender.

Relationships Among Response Categories

There were no noteworthy intercorrelations involving these categories.

Rare and Unique Responses

Most responses concerning the nature and uses of maps were straightforwardly captured by the coding categories, with the following exceptions.

Kindergarten: Pirates need maps to find their treasure; if you have no idea about places that you might want to visit that you have never been to, you could look at maps for ideas; you use maps on treasure hunts; pirates use them; road racers use them.

First grade: Pirates use them.

Second grade: None.

Third grade: There are two kinds of maps—one to look at and locate places (atlas or broad geography map) and one to tell you how to get there (smaller-scale road map).

Discussion

There is little to say about responses to Question 23 other than that most students understood the nature and function of maps and no misconceptions were expressed.

Foreign Travel

Question 24 addressed students' awareness of the fact that travel across national borders is typically restricted and may require presentation of a passport or proof of permission to enter the country.

Question 24. If people want to go to another country, can they just go, or do they have to get permission? (If they need permission, who do they have to get permission from?) (If student speaks of a child asking parental permission, ask, **Do grown-ups have to get permission to go to another country?)**

Almost a fifth of the students (six kindergarteners, eight first graders, three second graders, and one third grader) initially answered the question in terms of children needing to get travel permission from their parents. After clarification, most of these went on to indicate that parents wouldn't need permission. Several other students spoke of people getting permission from their boss, from the hotel or the people with whom they would be staying when they arrived, or from the airlines. In all of these cases, the interviewer probed to focus the students on the issue of needing permission from governments. The coding categories for Question 24 therefore reflect the students' understandings related to this particular issue.

The data shown in Table 1 indicate that 13 students were unable to respond to this question, 39 said that people can just go without needing to get permission, and 44 said that they need permission. However, only 17 of the latter students clearly understood that this permission would have to be granted by government officials. The others spoke of permission from hotels, airlines, etc.

Even the students who believed that travelers need permission from governments were relatively vague about the officials or processes involved. Seven of them referred to getting permission from the police or from officials at the border and various others spoke of getting permission from the government, the king, or the president. Only one student mentioned a passport and none mentioned a visa. The following examples from average-achieving boys and girls are representative of the responses from the students across the four grade levels.

Kindergarten

Jered

24. Permission. (Who do they have to get permission from?) I don't know.

Kate

24. They have to get permission. (Who do they get permission from?) A person. (Who's the person?) I don't know. Any person.

First Grade

Chris

24. They can just go.

Lauren

24. If you're grown up, you probably won't need permission. (OK, so grown ups don't need to have permission to go to another country, or do they?) They need to ask their kids and they need to ask if any other people want to go.

Second Grade

Mark

24. They can just go.

Emily

24. They can just go, but if they're at work and they need to do something on the day they need to go, they might ask their boss if they can do it the next time they come when they get off their vacation.

Third Grade

Dale

24. They have to get permission because they have to have this card, because my teacher says you have to have this card. (So you're saying you need a card and your teacher had a card?) Yeah, you have to have a card and you can't bring anything back usually, and you have to have a card to get past, like if you want to go to China, you have to have this card that says . . . and you can't bring any of your . . . I think you might be able to bring some of your money there. I don't know.

Chelsea

24. Sometimes they have to get permission, but if they're like a parent, they can go. (Who do they have to get permission from?) If you're a little kid and you want to see your grandma or something, then you have to have permission from your mom or dad. (Do grown ups have to get permission to go to another country?) Well, sometimes they do because sometimes if they want to go with some friends, then they have to get a baby sitter and the baby sitter might not want to stay that long, so that's sort of permission but sometimes it's not.

Grade Level Differences

There was one significant linear relationship with grade level, indicating that older students were more likely than younger ones to state correctly that permission would be needed from the governments involved. However, two nonlinear relationships with grade level were also observed: First graders were more likely than other students to be unable to provide a substantive response to this question but less likely than other students to say that travelers need permission. Thus, the grade-level differences did not follow expected patterns as clearly for this question as for most others, apparently because the question was very difficult for the students, so most of them were guessing rather than working from a base of accurate knowledge.

Achievement Level and Gender Differences

The four categories for responses to Question 24 yielded three significant relationships with grade level but none with achievement level and only one with gender. The gender difference appeared because 12 boys but only 5 girls knew that international travelers must get permission from the governments involved.

Relationships Among Response Categories

None of the categories for responses to Question 24 showed noteworthy correlations with categories for responses to other questions. This is not surprising given the tendency of these categories to show nonlinear relationships with grade level and achievement level.

Rare and Unique Responses

Kindergarten: None.

First grade: None.

Second grade: You can leave our country without permission, but in some countries you can't (goes on to refer to Elian Gonzales); to go to Russia, you would have to get a green card if you were going to stay for the rest of your life, but otherwise you could just go.

Third grade: You have to have this card saying what you are bringing to or from the country; if you are divorced and want to take your children out of state, you need permission from your ex-spouse; you need a passport.

Discussion

With the exception of three or four of those who made unique responses, the students knew little or nothing about what is involved in traveling across national borders. Consequently, most were unable to respond to the question, guessed that people can just go without getting any permission from anyone, or guessed that they needed permission (and in that case, further guessed about from whom the permission would have to be obtained). This pattern of responses is just one of many manifestations throughout our interviews of the fact that the knowledge of students at these age levels is primarily limited to the micro-level of families and neighborhoods. Even among second and third graders, only about one-fourth of the students said that travel permission would have to be obtained from governments, and most of these students were guessing.

Traffic Control

The last question asked why we need stoplights, as a way to assess students' awareness of the need for governments to control the flow of traffic and of the chaos that would result if these controls were not in place.

Question 25. Why do we need stoplights on our streets? . . . What would happen if we didn't have them?

This question proved to be relatively easy for most students. Only six of them could not respond, and a heavy majority (83) said that without stoplights there would be many more accidents on our streets. Other responses indicated that stoplights control traffic and make sure that people stop for each other (46), that cars would crash if we did not have them (33), that

pedestrians would find it difficult to cross busy streets safely without them (10), or that they fulfill other functions such as preventing traffic jams and keeping people from traveling too fast. The following examples from average-achieving boys and girls are representative of the responses from the students across the four grade levels.

Kindergarten

Jered

25. Because they keep yourself safe. The red light is stop to keep you safe, then the yellow light is slow down to keep you safe, and the green light means go. (How do they keep you safe?) Because even if it's busy and the light's green, stay there until the traffic is stopped and all the cars have gone this way. (What would happen if we didn't have stop lights?) You could crash into another car.

Kate

25. Because to see if there's any cars going by. (What would happen if we didn't have them?) You could get in a car accident.

First Grade

Chris

25. Because the other cars are going left. They could turn and the other people are going right and they can turn. (What would happen if we didn't have stop lights?) We could just go through and they can go zzzzooommm and then crash. (What would happen to people if we didn't have stop lights?) They could just go straight and the other cars can go straight and the other car could just go boom right into one.

Lauren

25. Because they tell people if cars are coming other ways. (Any other reasons why we need stop lights?) No. (What would happen if we didn't have stop lights?) Then sometimes we won't have any cars because they're all going to be in a car crash. (Why would there be car crashes if they weren't any stop lights?) Because they wouldn't know if the cars were coming your way because they got to keep their eye on the way they're going.

Second Grade

Mark

25. So then like if somebody's coming like this, so then they don't bash into each other. (OK, so how do the stoplights keep people from bashing into each other?) If there's a lot

of traffic coming like this, then this light turns red, and then you have to wait until all the cars go past, and then it turns green and you can go.

Emily

25. Because there might be someone coming the same way as you and needs to go right where you are and if there weren't any stop lights, he might bump into cars.

Third Grade

Dale

25. So you could see, because if you wanted to walk across the street and the cars could only see you and you'd walk and you couldn't see that well, and if it's a car that's a dark color like a black car that you can't see, then you'll get hit. (What would happen if we didn't have stop lights?) You'd get killed easily.

Chelsea

25. Because if we didn't have stop lights, then everybody would crash and it would be a big disaster and everybody . . . most of the people would be killed and we don't want that so we put stop lights up, and now they take turns, but sometimes they don't because they just want to go and sometimes there's accidents, but most of the time there's stop lights and they don't crash, but sometimes they do.

Grade Level Differences

All six of the students who were unable to respond to this question were kindergarteners or first graders. Older students were more likely than younger students to say that stoplights minimize accidents and that they control traffic and make sure that people stop for each other. There was a nonlinear relationship with grade level for responses focusing on the problems of pedestrians attempting to cross busy streets. These responses were made more often by kindergartners and third graders than by first graders or second graders. In general, the older students made more sophisticated responses to this question than the younger students did, although even most of the younger students answered it adequately.

Achievement Level and Gender Differences

The six categories for responses to Question 25 yielded four significant relationships with grade level, but none with achievement level or gender.

Relationships Among Response Categories

Students who said that without stoplights there would be many more accidents were more likely than other students to also say that cars would crash if we did not have stoplights or that stoplights control traffic and make sure that people stop for each other. Otherwise, the only

noteworthy intercorrelations involving these categories are relationships between the more sophisticated responses and the maturity set for the interview as whole.

Rare and Unique Responses

Most responses to this question were well represented in the coding categories. The only unique response worth noting was one student's statement that stoplights tell us whether cars are coming the other way (unexplained further).

Discussion

The vast majority of the students understood the need for stoplights, at least at the level of controlling traffic flow so as to minimize accidents. However, few if any of them seemed aware that stoplights also make traffic more efficient, so that people are able to get to their destinations more quickly and easily than they would if traffic were not controlled.

General Discussion

Compared to responses to previous interviews (on shelter, clothing, food, and communication), responses to the transportation interview were generally more accurate (as far as they went) and less riddled with misconceptions. Perhaps this was because most of our questions addressed relatively concrete and observable functions and uses of modes of transportation, rather than their underlying natures (with the notable exception of the question about what makes a car go). However, two major limitations in the responses should be noted. First, on many of the questions, surprisingly high percentages of the students were unable to provide a substantive response. Second, the responses that were provided almost always focused on the micro-level of the activities of individuals or families, without addressing the macro-level of society in general or the world at large. As a result, students frequently missed the point of or gave only very limited responses to certain questions, especially questions about the impact of inventions.

Responses to the first question indicated that two-thirds of the second graders and over 90% of the third graders were able to define the term "transportation," but this was true of only one kindergartener and one first grader. Compared to their responses concerning food, clothing, and shelter, the students were less likely to say that transportation is a basic need. Even so, a heavy majority of them did make this response. The students who were able to respond to these questions typically defined transportation as moving from one place to another or as a conveyance or vehicle that can be used to accomplish such movement. About two-thirds cited local travel needs (to get to school, work, a doctor's office, etc.) in explaining the need for transportation, although some students emphasized long-distance travel or said that people need transportation when they do not have a car.

The next questions assessed students' knowledge about transportation in three time periods: the cave days (prehistoric times), the pioneer days (early 18th century), and the present. Most of what the students who responded had to say was accurate or at least defensible in characterizing travel at these three time periods, although almost a sixth could not respond

concerning the cave days and almost a third could not respond concerning the pioneer days. Most of the students correctly said that people walked in the cave days, although minorities said that they rode animals, used carts or other wheeled vehicles, used "Flintstone" vehicles with stone wheels, or used modern vehicles. Only 38 students made reference to wagons, covered wagons, buggies, or other animal-pulled vehicles in talking about the pioneer days. Other students were unable to respond, said that the pioneers used ships or that they had to walk everywhere, or said that they used modern vehicles.

Almost all of the students mentioned engine-powered vehicles in talking about transportation in modern times. In general, the students seemed to understand the progression from walking and carrying or dragging things to animal-powered wheeled vehicles to engine powered wheeled vehicles. However, some of them were badly confused about when these progressions occurred, and a few believed that cave people used the types of stone vehicles shown in the Flintstones cartoon on television.

The next set of questions addressed students' understanding of the ways that key innovations in transportation (the Native Americans' acquisition of horses, the building of railroads, the construction of highways, and the coming of airplanes) brought new opportunities into people's lives and "shrunk the world" by developing connections between formerly isolated places. Although inability to respond was a frequent problem, most of what was said in response to these questions was accurate or at least defensible. Most students easily grasped the big idea that each successive transportation innovation made it possible for people to travel farther, quicker, and easier than before. However, the responses focused on the ways that improvements in travel affected individuals (e.g., Native Americans would not have to expend as much energy or get as tired or footsore as they did formerly when they had to walk everywhere; when trains became available people could ride them to get places more quickly and in more comfort). Very few students answered these questions with reference to macro-level changes in society or the world at large.

When asked about how transportation innovations had "made the world smaller," the majority could not respond and most of the rest took the statement literally and said that transportation-related construction (of highways, train tracks, airports, etc.) took up a lot of space and thus reduced the space available in the world for other uses. Only two students grasped the metaphorical meaning of "made the world smaller" and spoke of people now being more connected to one another, and no students mentioned, for example, that horses allowed the plains tribes to follow the buffalo over much greater distances or that railroads, highways, and airplanes transformed the nation and the world from a collection of mostly isolated settlements into a richly connected social and economic network.

Misconceptions in responses to these questions were mostly minor and infrequent. However, several students were under the impression that trains cannot cross rivers and that all highways are literally high—built significantly above the surrounding land. Other misconceptions included the ideas that Indians found it harder to hunt food with horses because they scared away the buffalo, that horse-drawn buggies were faster than trains, that highway travel is slow because it takes hours to get where you are going, and that it is not possible to

drive from Michigan to Florida because the way is blocked by a significant body of water that one must fly over.

The next set of questions addressed students' understanding of the principle that human populations tend to concentrate along travel routes and to be bounded by significant geographical barriers, especially mountains. Here again, the students' responses tended to be accurate as far as they went but limited to the micro-level of purview. Thus, they talked about early cities being built near oceans or on rivers because the people wanted to swim or play in the water, travel locally by boat, fish, or simply take aesthetic pleasure in viewing the beauty of the water or listening to the sound of the waves. Only a minority displayed awareness that water is necessary to human survival and only a few conveyed awareness that in the distant past, much exploration and long-distance travel was done on waterways.

Similarly, students generated various reasons why people might want to build cities along rail lines (because they wanted to be able to ride the train to go places, etc.), but few of them showed awareness of rail lines as vital links to other communities, sources of access to goods and markets, etc. during those times. Furthermore, some showed elements of reversed reasoning in thinking that the tracks were built first and then settlements were built along them primarily to serve the needs of the trains and their riders, not realizing that tracks ordinarily are laid to link communities to which people want to travel and the trains operate to serve the needs of the people in these communities. That is, although it is true that the opening of a new travel route tends to energize the economies of already-existing settlements along the routes and sometimes to stimulate the development of new settlements, the cause-effect chain usually begins with recognition of the need for a better travel route between two or more already-existing communities.

Finally, the students again generated various reasons why it is easier to cross mountains today than in the past (e.g., better mountain-climbing equipment, engine-powered vehicles), but few of them showed any awareness of mountains as significant barriers to transportation until the relatively recent past.

The next set of questions further probed students' understanding of historical developments in transportation, and the students' responses once again focused on micro-level events. When asked why the wheel was an important invention, a majority said that wheels are needed for vehicles and smaller numbers said that wheels allow us to move things more easily without having to drag them or to travel more quickly than we can travel in non-wheeled conveyances. These responses are accurate and most show at least some appreciation of the fundamental importance of the wheel. However, few students showed any awareness of the wheel's far-reaching impact or the ways that society at large (not just personal travel) would be very different without it.

When asked whether the Pilgrims would have been able to drive across the country if they had cars with them, a majority of the students incorrectly said that they would have been able to do so, and most of the others were unsure or only made reference to barriers such as rivers, mud, snow, or the lack of gas stations. Only 15 students clearly understood that the

Pilgrims would not have been able to drive across the country because it was a heavily forested and roadless wilderness at the time.

When asked how our lives would be different if we had only horses and wagons to get around in, most of the students who were able to respond said that travel would be slower or more difficult. However, few of them conveyed any indication that they were visualizing major changes in society as a whole. Similarly, when asked how our lives would be different if we had trains but no cars today, the students were usually able to say that travel would be less convenient, but few of them showed awareness of ways that society at large (not just personal travel) would be different.

Responses to questions about the impact of travel innovations made it clear that the students were more aware of water than of mountains as formidable barriers to long-distance travel, and they were much more heavily focused on personal travel than on the transportation of goods or raw materials. Finally, they were often vague or confused about the reciprocal relationships between the development of travel routes and the location of settlements along these routes. These and other limitations in the students' responses, along with their frequent inability to respond at all, suggest that K-3 students stand to benefit from systematic instruction on the impact of transportation innovations on both micro- and macro-level aspects of the human condition at the time period involved.

Such instruction might begin by establishing that prior to the invention of the wheel, people had to walk everywhere and carry or drag anything that they needed to move. Wheeled vehicles simplified these transportation tasks enormously, especially once people learned to use large animals to pull them. This also enabled people to travel farther and faster, thus coming into contact and engaging in trade with more of the people in their part of the world. This in turn speeded up the spread of inventions and other products of culture. Even with ox carts or comparable wheeled conveyances, however, travel was slow and difficult; frequently impeded by deep rivers, thick forests, or hilly terrain; and bounded by large bodies of water, deserts, or mountains. Improvements in shipping and the development of ports that linked land and water routes made it possible to overcome some of the water barriers to travel, and sometimes travel between oases made it possible to cross deserts and travel through passes made it possible to cross mountains. Still, these forms of travel were slow and their capacities for moving goods and raw materials were limited. Thus, until recently in human history, most people made do with products grown or manufactured locally and never traveled very far from their homes.

This changed dramatically with the development of engine-powered vehicles, first trains and later ships, cars, and planes. Once the needed infrastructure (train tracks and stations, port facilities, highways, airports, etc.) developed to allow these forms of transportation to proliferate, it became possible to travel at much more rapid speeds, to move heavy loads of not only people but products and raw materials, and to cross deserts, oceans, and mountains quickly. Communities sprung up along travel routes, not only to service the travelers but to process farm products for shipment to markets and raw materials for shipment to factories. People could not only accomplish local travel more easily but enjoy products brought in from a much broader range of places and migrate more easily if life was difficult for them at their place of birth.

Communities became more connected to other communities, and eventually the world became one big network with lots of interconnections.

K-3 students should be able to understand these and related big ideas about macro-level changes in society, especially if they are presented with frequent reference to micro-level implications and examples. Maps and other artifacts could be used to illustrate the effective size of the "world" inhabited by a child or family living at a particular time and place in history, with emphasis on the ways in which available travel affordances and limitations affected the directions and distances that this "world" extended from the local community (and the implications of this for access to other people, cultures, products, and inventions).

Our question about the effects of building a highway through a small country town also produced micro-level responses focusing on how the highway would make it harder for individuals to get out of their driveways, create irritating noise or pollution, or allow them to get out of town more quickly. Only a few responses addressed how the highway would change the town as a whole. The students were much more aware of potential negative effects than positive ones. Except for a few references to construction of more houses or other buildings, the students seemed unaware of the effect of a highway in stimulating the local economy.

Similarly, responses to the question about the impact of trucks on farmers elicited responses talking about how individual farmers might use their trucks but not about how the trucks transformed the nature and scope of farming as a business. Responses to the next question conveyed very little awareness of the role of transportation in bringing fresh farm products to our local stores all year round. This lack of awareness was associated with a more fundamental lack of awareness that the farm products sold in stores during the winter have been transported from other states or nations. A majority of the students harbored the misconception that apples purchased locally in the winter were grown locally, picked in the summer or fall, and then preserved for sale in the winter. Some of the students talked about chilling the apples or taking other steps to preserve them, so at least they were aware that apples eventually rot. Nevertheless, even these students were under the impression that the apples had been grown locally and preserved, not imported from elsewhere. This misconception appeared in a majority of even the third graders' responses. Thus, K-3 students would stand to benefit not only from general instruction on the role of transportation in bringing products from elsewhere to our local stores, but more specific instruction about how fresh fruits and vegetables are only available in season and the ones that we purchase in other parts of the year are imported from elsewhere.

When asked about forms of transportation found in big cities but not in other places, a surprising 40% of the students were unable to respond and more than half of the rest incorrectly mentioned cars, trucks, or vans. Apparently, the qualification "but not in other places" did not register with most of the latter students. There remaining answers to questions about urban transportation were more accurate. Most of the students understood that city dwellers often ride trains, buses, or subways because they do not have cars or because public transportation may be cheaper, faster, or more convenient for them than driving/parking in a congested inner city. Also, a heavy majority of the students understood that taxis are cars hired for local transportation by people who do not have a car available at the time. Older students usually knew that the fare

is determined by the length of the trip as well, but younger students usually were unable to respond or could only guess how fares are determined.

When asked how a car works—what makes it go—the students typically began by mentioning the engine or gasoline or various other car parts, then went on to respond to probes by talking about the steps that the driver goes through in starting the car or causing it to begin moving. These responses were generally accurate as far as they went (you need a key to start the car, you push on the gas pedal, the engine makes the wheels turn, etc.). However, fewer than half of the students mentioned the engine, and for a majority of them, the engine was a black box. Individual students mentioned quite a number of car parts in struggling to explain what makes the car go, but these terms often were used in ways that showed that the student did not understand their meanings or functions. No student gave a clear explanation subsuming the key elements that gasoline (mixed with air) is burned within the cylinders to create explosions that move the pistons, and this piston movement in the engine is transferred to the axle to make the car's wheels move. Three students did supply partial explanations that talked about piston movement in the engine resulting in movement of the wheels and thus the car, but none of them mentioned burning of gasoline or explosions that get the pistons moving.

Several students talked about gasoline starting out in the gas tank, then traveling throughout the car, and eventually coming out the exhaust in gaseous rather than liquid form. These students understood that gasoline is necessary to the car's operation, but they had only black-box theories of the engine or other workings of the car. Again, only a few students mentioned that the gasoline is burned, and none mentioned explosions that initiate piston movement.

Not surprisingly given their previous responses concerning the effect of building a highway through a small country town, the students (except for those unable to respond) found it easy to answer our question about problems that exist in places where most people drive cars or trucks. Most of them named at least one problem associated with a concentration of motor vehicles (accidents, traffic jams, congestion, noise, or pollution), and none communicated misconceptions.

The students also understood the nature and functions of maps. Almost all of them were able to define and/or describe maps and talk about when and why people use them. Again, no misconceptions were expressed.

When asked whether people wanting to travel to a foreign country need permission, many students initially responded in terms of children getting permission from their parents. Once this was clarified, most students said either that adults do not require permission to travel to other countries or that they need permission from airlines, hotels, or people with whom they will be staying. Only 17 students clearly understood that travelers require permission from the governments of the countries involved. Only one student mentioned a passport and none mentioned a visa.

The last question asked why we need stoplights and what would happen if we didn't have them. This proved to be relatively easy for most students. A heavy majority said that without

stoplights there would be many more accidents in our streets, and some went on to mention other factors such as that the lights make sure that people will stop for each other, that pedestrians can cross the streets safely, or that people do not travel too fast. However, few if any of the students seemed aware that stoplights also make traffic more efficient, enabling people to get to their destinations more quickly and easily than they would if traffic were not controlled.

Grade Level Differences

Significant relationships with grade level were observed for 107 of the 168 coding categories shown in Table 1. Of the 107 significant relationships, 100 were for linear trends and the other 6 were for nonlinear relationships. The 101 linear trends can be summarized simply by stating that the younger students were more likely to be unable to respond or to be coded in categories reflecting low-level responses, whereas the older students were more likely to be coded in categories reflecting sophisticated responses. In a few cases, a response expressed more often by older students fell short of an ideal response to the question (e.g., innovations in transportation have made the world smaller because transportation-related construction takes up a lot of space), or even was incorrect (e.g., the apples purchased in Michigan stores in the winter are grown locally, picked in the summer or fall, and then preserved for sale in the winter), but this response was still preferable to the response category coded more frequently for younger students (typically, inability to respond to the question at all). Where significant relationships with grade level were observed, the relationships indicated increases in knowledge across the K-3 grade level range. In some cases, however, even the third graders were mostly unable to answer a question adequately (e.g., not realizing that the Pilgrims would not have been able to drive across the country even if they had cars because at the time it was a heavily forested roadless wilderness, not realizing that apples are imported from elsewhere during the winter, not knowing that international travel requires permission from the governments involved).

Achievement Level and Gender Differences

Only 23 of the 168 categories showed significant relationships with achievement level. Of these, 23 were linear trends and 3 were nonlinear relationships. Most of the linear trends could be summarized simply by stating that lower achievers were more likely to be unable to respond or to give low-level responses to the questions, whereas higher achievers were more likely to give sophisticated responses. Overall, however, the frequency of significant relationships with achievement level was lower for the transportation interview than for our previous interviews. We continue to find that the quality of the responses is associated much more closely with grade level and personal experiences outside of school than with achievement level or gender.

Significant gender differences appeared on only 14 of the 168 response categories, 9 favoring boys and 5 favoring girls. Most of these categories reflected minor or stylistic differences in response to the questions rather than noteworthy differences in knowledge. Gender differences also were less frequent and less patterned for the transportation interview than for previous interviews.

Limitations of the Study

Our interviewers generally established good rapport with students and our questions were tailored for the age levels involved, so we believe that our findings comprise a generally valid representation of the nature and development of K-3 students' knowledge and thinking about transportation as a cultural universal. Some of the students might have been more responsive if they had been interviewed on another day. All of them might have been able to say more if we had included illustrations to provide visual stimuli. However, we believe verbal questions alone were sufficient to enable the students to understand what we were asking. Also, we have found that illustrations tend to "stimulus bind" children's responses, and we prefer them to respond using their own images of the objects, events, or processes we ask them about, not images that we might supply by showing them a photo or other illustration.

The sample was large enough to allow population differences by grade level, achievement level, or gender to be detected via statistically significant Chi-squares in our analyses. However, it was limited in at least three respects. First, it was limited to the lower middle portion of the socioeconomic status (SES) range. No subsamples representing the upper or lower SES levels were included.

Second, even though the sample was open to students of any race or ethnicity (as long as all or at least most of their lives had been lived in the U.S.), the population of the community involved was such that the students we interviewed were overwhelmingly European American in their ethnic composition. Few students from African-American, Asian-American, Latino, or Native American families were included. We believe that children's ideas about transportation are more likely to be influenced by their common experiences growing up within the contemporary U.S. society and culture than by differences in their family backgrounds, so we do not believe that this sample limitation is as serious as it might have been if we were asking questions about race or ethnicity. This is an untested assumption, however, and it remains to be seen whether our findings will generalize to racial and ethnic minorities.

The third limitation in the sample was geographic. The students all lived in Michigan. It is possible that somewhat different patterns of response to at least some of our questions might have been elicited from students living elsewhere.

Another limitation of the study is its lack of systematic data on the origins of students' ideas. Interviewers were instructed to ask students about where they got their information when they gave unusually sophisticated or detailed responses, but we did not routinely ask about the sources of the students' information. This was because we view the work as initial, establishing-the-parameters research in an emerging field, rather than as more specifically targeted research in a more mature field. We are trying to establish initial norms or parameters concerning five-to-eight-year-old American children's knowledge and thinking about cultural universals, not to trace the origins of the knowledge, to establish the mechanisms through which development occurs, or to address other issues that might become more relevant farther down the road. This "outline the big picture first, then start filling in the details" approach is the way that science normally proceeds in emerging fields.

We assume that particular subsets of knowledge and thinking are developed through a mixture of mechanisms that will vary with the topic. For example, a lot of spontaneous knowledge development probably occurs in learning about aspects of cultural universals that are observable in the home and neighborhood. In contrast, most of what is learned about aspects that existed in the past or currently exist only in other areas or cultures would have to be learned primarily through transmission of knowledge (initially from family members and the media, later at school). Eventually we will learn more about the mechanisms through which knowledge is acquired, what experiences lead to growth or change outside of school, how easy or difficult it may be to teach particular networks of knowledge in school, and what materials and methods may be helpful in doing so.

Implications for Primary-Grade Social Studies

In the introduction to this report we noted that Ravitch and others have claimed that primary-grade students do not need to be taught about cultural universals because they already know this information, having picked it up through everyday life experiences. This may be true for the very limited and trite information contained in many primary-grade social studies textbooks. We have no doubt that most children do develop intuitive understandings of these ideas through informal life experiences, and further that those who have not developed the ideas on their own are likely to understand them readily when they are pointed out by a teacher.

However, our findings are showing that children do not routinely acquire all, or even a significant portion, of what is worth knowing about cultural universals through everyday experiences (primarily because these experiences are informal and do not include sustained discourse structured around key ideas). Furthermore, the mostly tacit knowledge that they do accumulate is limited, disconnected, and frequently distorted by naïve ideas or outright misconceptions. We conclude from this that primary-grade students do stand to benefit from instruction about cultural universals, although the kind of instruction that we envision is much more coherent and powerful than the kind that students are likely to receive from teachers who confine themselves to the content in the major publishers' elementary social studies textbook series and the questions and activities suggested in the accompanying teachers' manuals.

We believe that such instruction belongs in the primary-grades social studies curriculum, although in addition to (not instead of) efforts to develop students' prosocial values and dispositions and a variety of skills ranging from map reading to critical thinking and decision making. The questions asked in this study reflect our notions about key ideas that might be emphasized in teaching about transportation. Some of them might be classified more readily as science than social studies, but they all tap networks of knowledge that we believe to be basic for developing initial understandings of the topic. Like others who have focused on the primary grades, we believe that the curriculum in these grades should feature pre- or pandisciplinary treatments of topics designed to develop "knowledge of limited validity" (Levstik, 1986) or "protodisciplinary knowledge" (Gardner & Boix-Mansilla, 1994) about the topic, rather than attempts to teach children disciplinary knowledge organized as such.

We favor an appropriate balance between the three traditional sources of curricula (knowledge of enduring value, including but not limited to disciplinary knowledge; the students'

needs, interests, and current zones of proximal development; and the needs of society in terms of the knowledge, skills, values, and dispositions that our society would like to see developed in future generations of its citizens). Within this context, we argue that a pandisciplinary introduction to the social world (past and present, taught with emphasis on developing understanding, appreciation, and life application of big ideas) makes more sense for primary-grade students than what we view as premature attempts to socialize these students into the academic disciplines.

In conclusion, we believe that primary-grade students stand to benefit considerably from curricular treatments of cultural universals that are more powerful than those typically offered by textbook series. We define powerful treatments as treatments that enable students to develop understanding of how the cultural universal addressed in the unit works in our society, how and why it got to be that way over time, how it varies across locations and cultures, and what all of this might mean for personal, social, and civic decision making.

Such units would still focus on elementary and familiar content in that they would address fundamental aspects of the human condition and connect with experience-based tacit knowledge that students already possess. However, they would not merely reaffirm what students already know. Instead, they would raise students' consciousness of, and help them to construct articulated knowledge about, basic aspects of the cultural universal about which they have only vague and tacit knowledge (this refers to aspects that are concrete and comprehensible to them given their limited cognitive structures and prior knowledge; aspects that were too abstract or macro analytic would not be included). Such units also would introduce students to a great deal of new information, develop connections to help them transform scattered understandings into a network of integrated knowledge, and stimulate them to apply the knowledge to their lives outside of school and to think critically and engage in value-based decision making about the topic. For more information about such units, see Brophy and Alleman (1996), and for detailed unit plans, see Alleman and Brophy (2001, in press a, in press b). The Alleman and Brophy (in press b) volume includes plans for an instructional unit on transportation.

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APPENDIX A.

TRANSPORTATION INTERVIEW

TRANSPORTATION INTERVIEW

1. **TODAY WE'RE GOING TO TALK ABOUT TRANSPORTATION. WHAT DOES TRANSPORTATION MEAN?** (If student does not know, explain that transportation refers to how people travel or get from one place to another.)

2. **IS TRANSPORTATION JUST SOMETHING THAT PEOPLE ENJOY, OR DO THEY NEED IT? . . . WHAT ARE SOME TIMES WHEN THEY NEED IT?**

3. **LET'S TALK ABOUT TRANSPORTATION IN THE PAST. HOW DID PEOPLE GET AROUND WAY BACK IN THE DAYS WHEN THEY USED TO LIVE IN CAVES? . . . HOW DID PEOPLE GET AROUND DURING THE PIONEER DAYS? . . . WHAT KINDS OF TRANSPORTATION DO WE USE NOW THAT PEOPLE LONG AGO DIDN'T HAVE?**

4. **FOR A LONG TIME, THE NATIVE AMERICAN INDIANS DIDN'T HAVE HORSES, BUT THEN THEY GOT HORSES. HOW DID HAVING HORSES CHANGE THEIR LIVES?**

5. **FOR A LONG TIME, PEOPLE HAD ONLY HORSES AND WAGONS TO GET AROUND IN, BUT THEN THE RAILROAD WAS BUILT. WHAT COULD PEOPLE DO AFTER THE RAILROAD WAS BUILT THAT THEY COULDN'T DO BEFORE?** (If necessary, **WHY WOULD THEY CHOOSE TO DO THAT?**)

6. **LATER, HIGHWAYS WERE BUILT. WHAT COULD PEOPLE DO AFTER HIGHWAYS WERE BUILT THAT THEY COULDN'T DO BEFORE?**

7. **THEN, AIRPLANES WERE BUILT. WHAT COULD PEOPLE DO AFTER AIRPLANES WERE BUILT THAT THEY COULDN'T DO BEFORE?**

8. **SOME PEOPLE SAY THAT ALL OF THESE CHANGES IN TRANSPORTATION HAVE "MADE THE WORLD SMALLER." WHAT DO THEY MEAN BY THAT?** (If necessary, **HOW HAVE RAILROADS AND CARS AND AIRPLANES MADE THE WORLD SMALLER?**)

9. **LONG, LONG AGO, PEOPLE BUILT CITIES NEAR OCEANS OR ON BIG RIVERS. WHY WAS THAT?**

10. **LATER, PEOPLE BUILT CITIES ALONG RAILROAD LINES. WHY WAS THAT?** (If necessary, **WHY DID THEY <u>WANT</u> TO LIVE BY THE RAILROAD LINES?**)

11. **AT ONE TIME, MOUNTAINS MADE IT HARD FOR PEOPLE TO TRAVEL. MOST PEOPLE DIDN'T EVEN TRY TO CROSS MOUNTAINS, BUT NOW WE CROSS THEM ALL THE TIME. WHY IS IT EASIER NOW?**

12. **WHY WAS THE WHEEL AN IMPORTANT INVENTION? (WHAT COULD PEOPLE DO AFTER THE WHEEL WAS INVENTED THAT THEY COULDN'T DO BEFORE?)** (If student starts talking about cars, ask WHAT ABOUT BEFORE **CARS WERE INVENTED—WHY WAS THE INVENTION OF THE WHEEL IMPORTANT?**

13. **IF THE FIRST PILGRIMS TO COME TO THE NEW WORLD HAD CARS—COULD THEY HAVE USED THE CARS TO DRIVE ACROSS THE COUNTRY?** (If yes, **HOW WOULD THEY HAVE DONE IT?)** (If no: WHY NOT?) (If the student says that trees were in the way, ask **WHAT IF THEY CUT THE TREES DOWN?)**

14. **WHAT IF THERE WERE NO CARS TODAY? HOW WOULD OUR LIVES BE DIFFERENT IF WE ONLY HAD HORSES AND WAGONS TO HELP US GET AROUND?**

15. **WHAT IF WE HAD TRAINS BUT NO CARS? HOW WOULD OUR LIVES BE DIFFERENT? (HOW WOULD THAT AFFECT WHERE WE LIVED? HOW WOULD WE SHOP IF WE ONLY HAD TRAINS? HOW WOULD IT AFFECT WHERE WE WENT ON VACATION?)**

16. **SUPPOSE YOU LIVED IN A SMALL TOWN OUT IN THE COUNTRY AND A BIG HIGHWAY WAS BUILT RIGHT THROUGH IT. HOW WOULD YOUR TOWN BE DIFFERENT AFTER THE HIGHWAY WAS BUILT? (HOW WOULD IT BE BETTER? HOW WOULD IT BE WORSE?)**

17. **FARMERS PRODUCE FOOD FOR PEOPLE. A LONG TIME AGO, FARMERS DIDN'T HAVE TRUCKS. THEN THEY GOT TRUCKS. HOW DID THE FARMING BUSINESS CHANGE AFTER TRUCKS WERE BUILT? (HOW DID TRUCKS MAKE THINGS DIFFERENT FOR FARMERS?** (If necessary: **WHAT DIFFERENT WOULD IT MAKE IF FARMERS COULD TAKE PRODUCE TO MARKET IN TRUCKS?)**

18. **APPLES GROW HERE IN THE SUMMER, BUT NOT IN WINTER. BUT EVEN IN WINTER, WE CAN BUY APPLES. WHY IS THAT?** (If necessary: **SO YOU THINK THAT THE APPLES IN MEIJER'S WERE GROWN HERE IN MICHIGAN AND THEN FROZEN?)**

19. **WHAT KINDS OF TRANSPORTATION DO YOU FIND IN BIG CITIES BUT NOT IN OTHER PLACES? (WHY DO A LOT OF PEOPLE IN BIG CITIES USE BUSES OR SUBWAYS INSTEAD OF CARS?)**

20. **WHAT IS A TAXI CAB? WHY DO PEOPLE USE TAXI CABS? DO THEY HAVE TO PAY TO USE TAXI CABS?** (If yes, **HOW DOES THAT WORK? HOW DOES THE DRIVER DECIDE HOW MUCH YOU SHOULD PAY?)**

21. **HOW DOES A CAR WORK—WHAT MAKES IT GO?** (Probe for knowledge of gasoline-fueled engines.)

22. **IT'S NICE TO HAVE CARS AND TRUCKS, BUT THEY CREATE PROBLEMS TOO. WHAT ARE SOME PROBLEMS THAT EXIST IN PLACES WHERE MOST PEOPLE DRIVE CARS OR TRUCKS?** (Probe for knowledge of noise, traffic, pollution, etc.) (For students who respond in terms of breakdowns of one's own car, say **OK—THAT WOULD BE FOR YOUR CAR. BUT I WAS WONDERING IF PLACES WHERE THERE ARE A LOT OF CARS HAVE PROBLEMS BECAUSE THERE ARE SO MANY CARS THERE?)**

23. **WHAT IS A MAP? . . . WHEN DO PEOPLE NEED MAPS?**

24. **IF PEOPLE WANT TO GO TO ANOTHER COUNTRY, CAN THEY JUST GO, OR DO THEY HAVE TO GET PERMISSION? (IF THEY NEED PERMISSION, WHO DO THEY HAVE TO GET PERMISSION FROM?)** (If student speaks of a child asking parental permission, ask **DO GROWN-UPS HAVE TO GET PERMISSION TO GO INTO ANOTHER COUNTRY?**

25. **WHY DO WE NEED STOP LIGHTS ON OUR STREETS? (WHAT WOULD HAPPEN IF WE DIDN'T HAVE THEM?)**

Table 1. Distributions and Correlation Coefficients Showing Relationships of Coding Categories to Grade Level, Achievement Level, and Gender[1]

	Total Sample	Grade Frequencies K	1	2	3	Grade Phi	Achievement Level Frequencies Low	Avg.	High	Ach. Phi	Gender Frequencies M	F	Gender Phi
Number of Students	**96**	**24**	**24**	**24**	**24**		**32**	**32**	**32**		**48**	**48**	
1. What is transportation?													
0. Doesn't know/no relevant response	57	23	23	9	2	-77	19	21	17		28	29	
1. Names a vehicle or mode of transportation	10	1	0	4	5	28	2	4	4		3	7	
3. Moving someone or something	9	1	0	4	4	26	3	3	3		8	1	-25
4. Changing location, going from one place to another	30	0	1	12	17	65	8	10	12		14	16	
5. A means of getting around, conveyance, vehicle	12	0	0	3	9	46	4	2	6		3	9	19
2. Is transportation just something that people enjoy, or do they need it?													
1. Says that people need transportation, at least at times	86	21	18	23	24	31	27	29	30		44	42	

Table 1 (cont'd.)

2. People need transportation to get places: stores, school, work, home, hospital, doctor's office, friends' homes, etc.	61	13	12	18	18	24	21	21	19		29	32
3. Transportation needed to travel long distances (Florida, California, etc.)	23	4	6	4	9		8	7	8		12	11
4. People need transportation when they don't have a car (cabs, rides from friends, etc.)	7	2	1	2	2		0	2	5	25	3	4

3A. Let's talk about transportation in the past. How did people get around way back in the days when they used to live in caves?

0. Doesn't know/no relevant response	15	6	4	5	0	-26	6	4	5		5	10
1. They used modern vehicles or "Flintstone" vehicles made of stone	10	3	3	2	2		2	6	2		5	5
2. They rode animals: oxen, horses	10	1	0	5	4	28	3	4	3		4	6
3. They used carts, wagons, carriages, buggies	10	2	0	2	6	30	3	4	3		1	9	27
4. They walked	66	13	19	15	19		23	20	23		38	28	-22

Table 1 (cont'd.)

3B. How did people get around back in the pioneer days?

0. Doesn't know/no relevant response	30	13	10	5	2	-38	10	12	8	14	16
1. Modern vehicles: cars, taxis, buses, trains	8	4	3	0	1	-24	3	2	3	5	3
2. Walked	15	4	4	3	4		8	4	3	8	7
3. Boats or ships	14	2	2	1	9	38	2	6	6	9	5
4. Wagons or covered wagons	24	0	3	12	9	46	7	6	11	11	13
5. Oxen or horses	15	1	4	8	2	NL	6	3	6	9	6
6. Carriages or buggies	7	1	2	2	2		3	3	1	0	7
7. Mentions animal-pulled vehicles (coded 4, 5, and/or 6)	38	2	7	17	12	48	12	10	16	16	22

28

3C. What forms of transportation do we use now that people long ago didn't have?

0. No mention of motor vehicles (no response, walking, animals, bicycles, etc.)	5	3	2	0	0	-25	3	2	0	3	2
1. Common road vehicles: cars, trucks, buses, motorcycles	59	19	17	15	8	-36	20	21	18	28	31

Table 1 (cont'd.)

2. Common road vehicles plus trains, planes, or ships	32	2	5	9	16	46	9	9	14	17	15

4. For a long time, the Native Americans didn't have horses, but then they got horses. How did horses change their lives?

0. Doesn't know/no relevant response	22	13	5	4	0	-47	7	9	6	14	8
1. They could ride/ didn't have to walk (no elaboration)	18	5	4	4	5		8	5	5	10	8
2. They could go further or to other places	21	3	5	5	8	18	3	9	9	8	13
3. They could go faster	18	1	6	5	6	22	5	6	7	11	7
4. Riding is easier than walking: you don't have to use as much energy, you don't get as tired or foot sore, etc.	26	1	10	8	7	31	9	8	9	10	16
5. Riding made fighting, hunting, or finding food easier	14	1	1	7	5	31	6	4	4	9	5

5. For a long time, people had only horses and wagons to get around in, but then the railroad was built. What could people do after the railroad was built that they couldn't do before? . . . Why would they choose to do that?

0. Doesn't know/no relevant response	20	12	5	3	0	-45	8	8	4	10	10

Table 1 (cont'd.)

1. It's more fun, easier; they don't have to walk	13	4	1	6	2		7	4	2	-19	4	9		
2. Comfort: you can just sit and ride, shielded from the elements	7	1	3	1	2		3	0	4		3	4		
6. You can get to places faster/more quickly	48	4	17	12	15	41	12	15	21	23	28	20	-17	
7. You can get to places that are farther away, or to many more places	24	8	3	4	9		5	11	8		11	13		
8. Other: it's cheaper, you can carry more things, there is more space you don't have to stop as often to let horses rest, etc.	11	1	3	2	5		2	5	4		5	6		

6. Later, highways were built. What could people do after highways were built that they couldn't do before?

0. Doesn't know/no relevant response	18	11	2	3	2	-40	6	8	4		10	8		
1. They could drive cars, trucks, other road vehicles	27	7	8	6	6		11	7	9		15	12		

Table 1 (cont'd.)

3. They could go different or far away places; trains only go to stations; you could go across rivers, etc.	18	3	6	4	5		8	7	3		9	9	
5. They could stay clean and safe: highways are smoother, no dirt and dust, etc.	8	0	2	2	4	21	1	4	3		6	2	
7. They could travel up high instead of down lower (the roads were raised, they were on bridges that took them over other roads, etc.)	7	1	2	2	2		2	3	2		0	7	28
8. They could get places faster	25	2	8	8	7		6	6	13	24	11	14	

7. Then, airplanes were built. What could people do after airplanes were built that they couldn't do before?

0. Doesn't know/no relevant response	7	5	1	1	0	-31	4	3	0	-20	2	5	
1. Ride in the airplane (no elaboration)	9	5	1	0	3	NL	2	2	5		6	3	
2. Airplanes were more fun, easier, more relaxing	10	2	1	4	3		4	1	5		3	7	

Table 1 (cont'd.)

3. Airplanes don't have to stop at stop lights, run out of gas, get flat tires, deal with auto traffic, etc.	8	1	3	2	2		1	4	3		3	5
4. They could go to different states or countries (specifically named)	22	5	9	5	3		10	8	4	-19	10	12
5. They could go to far away places	28	5	4	7	12	28	5	12	11	21	12	16
6. They could go over water/oceans	9	1	4	2	2		2	4	3		3	6
7. They could get to places faster	42	7	14	12	9		14	15	13		24	18
8. Some people say that all of these changes in transportation have "made the world smaller." What do they mean by that?												
0. Doesn't know/no relevant response	56	21	17	12	6	-47	20	18	18		30	26
1. We have less space now because there are more buildings, vehicles, train tracks, airports, destruction of nature, etc.	30	2	6	8	14	39	9	10	11		14	16

Table 1 (cont'd.)

2. We can travel more easily/faster now, get places quicker; people are more connected with things and each other	8	0	0	4	4	30	2	3	3	4	4
9. Long, long ago, people built cities near oceans or on big rivers. Why was that?											
0. Doesn't know/no relevant response	31	10	10	6	5	-20	10	12	9	16	15
1. To view the beauty or the water; to listen to the waves	8	1	2	2	3		5	1	2	5	3
3. To swim or play in the water	24	5	9	7	3		10	6	8	9	15
4. To use the water (for drinking or washing)	27	5	4	9	9	21	9	9	9	14	13
5. To get food, fish from the water	15	4	1	7	3		7	4	4	8	7
6. To travel by boat or ship	23	3	8	6	6		7	7	9	14	9
10. Later, people built cities along railroad lines. Why was that?											
0. Doesn't know/no relevant response	33	12	10	5	6	-25	10	12	11	16	17

Table 1 (cont'd.)

1. They liked to watch the trains or listen to their noises	9	1	3	2	3		5	2	2	4	5	
3. So they could ride the train, go places	24	5	9	3	7		9	8	7	15	9	
4. So they could get to the train more quickly or easily	24	2	3	11	8	35	11	4	9	10	14	
5. So trains would have a place to stop/people would have a place to board trains	15	4	3	5	3		3	6	6	8	7	

11. At one time, mountains made it hard for people to travel. Most people didn't even try to cross mountains, but now we cross them all the time. Why is it easier?

0. Doesn't know/no relevant response	29	10	10	6	3	-27	10	9	10	14	15	
1. Better climbing equipment: ropes, backpacks, shoes, hooks, etc.	22	5	5	7	5		7	6	9	13	9	
2. Modern vehicles: drive cars on roads, take trains through tunnels to cross mountains	33	3	6	10	14	36	8	12	13	13	20	
6. Airplanes can fly over mountains	10	0	3	4	3		2	4	4	8	2	-20

Table 1 (cont'd.)

7. Mountains are smaller or less dangerous now (less snow, falling rocks, etc.)	9	4	3	2	0	-21	4	4	1		5	4
12. Why was the wheel an important invention?												
0. Doesn't know/no relevant response	18	7	6	3	2	-22	9	6	3	-20	9	9
1. People can go faster on things with wheels	20	0	6	5	9	33	4	8	8		8	12
2. You need wheels to use vehicles: drive cars, land planes, etc.	57	16	13	16	12		17	16	24	23	31	26
3. You can travel, move from place to place	21	4	4	4	9	22	5	10	6		12	9
4. You can move things more easily, don't have to drag them	27	1	4	9	13	43	7	8	12		12	15
13. If the first Pilgrims to come to the New World had cars, could they have used the cars to drive across the country?												
0. Yes, they could have	57	18	10	15	14		16	25	16	NL	28	29

Table 1 (cont'd.)

1. Doesn't know or mentions barriers other than those coded in Category 2 below (they would have to get around water, could get stuck in mud or snow, right run out of gas, etc.	24	5	8	5	6		9	7	8			11	13
2. They couldn't because trees/forests would be in the way/they couldn't until they made roads	15	1	6	4	4		7	0	8	NL		9	6

14. What if there were no cars today? How would our lives be different if we only had horses and wagons to help us get around?

0. Doesn't know/no relevant response	29	14	5	7	3	-38	10	11	8			14	15
1. Lists characteristics of horses: they get scared, tired, need feeding, etc.	14	1	6	4	3		4	3	7			6	8
2. We would have to walk more	12	3	6	2	1		6	3	3			5	7
3. It would be harder to get around	23	2	5	4	12	37	5	11	7			10	13
5. We couldn't get around as quickly	42	4	12	12	14	32	13	13	16			23	19

Table 1 (cont'd.)

15. What if we had trains but no cars? How would our lives be different?

0. Cannot respond or says only that we would ride trains	25	16	3	4	2	-54	10	8	7	11	14
1. Trains would be faster than horses	8	0	2	2	4	21	1	5	2	5	3
2. It would cost money to ride the trains	7	1	0	2	4	24	4	1	2	4	3
3. We would walk more	32	5	7	10	10	19	8	10	14	15	17
4. The trains would make noise	8	1	5	0	2	NL	2	1	5	3	5
5. Travel would be slower because of all the train stops	19	0	6	7	6	29	7	7	5	8	11
6. Talks about the hassle, crowding of train travel	17	1	2	3	11	43	6	7	4	8	9
7. Inconvenient because trains usually don't stop at the exact place you wish to reach	23	2	5	7	9	25	4	7	12	14	9
8. Trains cannot cross water	7	0	3	1	3		1	2	4	4	3

Table 1 (cont'd.)

9. We would want to live near the train station	20	2	8	5	5		8	8	4		9	11

16. Suppose you lived in a small town out in the country and a big highway was built right through the town. How would your town be different after the highway was built?

0. Doesn't know/no relevant response	26	13	10	3	0	-49	11	8	7		12	14
1. Destruction of houses, yards, parks, trees, gardens, nature; some people would have to move	17	2	4	7	4		4	5	8		8	9
2. It would be noisier	24	2	1	10	11	44	8	5	11		11	13
3. People could get to other places faster/ more easily	29	4	5	9	11	26	9	11	9		17	12
4. More or more dangerous traffic, more accidents, etc.	36	5	6	12	13	30	9	10	17	23	18	18
5. More houses and other buildings would be constructed	6	1	0	3	2		0	2	4	21	2	4
6. Other negative outcomes not included in previous categories: pollution, dust, bad smells, barriers to local travel, etc.	10	1	0	3	6	31	4	2	4		4	6

Table 1 (cont'd.)

7. Student mentions both positive and negative outcomes	20	2	0	8	10	42	3	8	9	20	11	9

17. Farmers produce food for people. A long time ago, farmers didn't have trucks, but then they got trucks. How did the farming business change after trucks were built?

0. Doesn't know/no relevant response	32	16	8	6	2	-45	12	13	7	14	18
2. They could get places faster	14	1	3	3	7	26	4	7	3	8	6
3. They didn't need to carry thing by hand or walking	14	1	5	1	7	31	6	5	3	7	7
4. They could use the truck to take things to and from markets	33	4	4	12	13	37	6	10	17	30	18	15
5. They could use the truck to do farm work	22	3	9	5	5		9	5	8		11	11

18. Apples grow here in the summer, but not in the winter. Even in the winter we can buy apples. Why is that?

0. Doesn't know/no relevant response	20	9	8	3	0	-38	7	8	5	12	8
1. Student talks only about the process of getting apples from trees to stores in the summer	9	7	1	0	1	-40	4	3	2	4	5

Table 1 (cont'd.)

2. Local apples picked in the summer are preserved for sale in the winter (possibly chilled, etc.)	52	6	14	15	17	35	17	14	21	27	25
3. Apples are imported from other states or countries	15	1	1	8	5	34	4	4	7	7	8

19A. What kinds of transportation do you find in big cities but not in other places?

0. Doesn't know/no relevant response	38	16	16	4	2	-56	15	12	11	18	20
1. Cars	36	4	7	16	9	38	12	13	11	18	18
2. Buses	23	3	2	11	7	35	7	4	12 NL	12	11
3. Trains	24	3	2	9	10	34	3	11	10 26	10	14
4. Taxis	13	0	1	5	7	35	6	2	5	9	4
5. Planes	16	2	0	6	8	35	2	7	7 20	10	6
6. Trucks and vans	14	1	4	5	4		7	2	5	10	4 -18
7. Other	14	4	3	2	5		4	4	6	8	6

19B. Why do people use buses or subways instead of cars?

0. Doesn't know/because they want to (without elaboration)	38	18	15	4	1	-61	15	14	9	18	20

Table 1 (cont'd.)

1. People don't have cars/ don't have money to pay for a car	20	0	4	8	8	34	9	5	6		9	11
2. Buses, subways go faster than cars	20	3	5	6	6		4	6	10	19	13	7
3. Traffic and stoplights impede surface travel	11	1	1	3	6	27	3	4	4		6	5
4. It's easier to travel on buses or subways/ you don't have to drive	9	0	2	2	5	26	2	4	3		4	5
5. Other (buses and subways are bigger, have more room for more people, etc.)	20	3	3	9	5		4	6	10	19	8	12
20A. What is a taxi cab?												
0. Doesn't know/no relevant response	12	6	5	1	0	-32	4	4	4		7	5
1. Describes taxi as a yellow or checkered car/ with taxi sign/number on the back, etc.	52	10	10	17	15	26	15	18	19	21	23	29
2. Something that takes people where they want to go	58	15	11	15	17		18	23	17		27	31

Table 1 (cont'd.)

3. A car that someone drives for you	25	4	6	6	9		12	6	7		13	12		
4. A car that you pay to use	24	1	5	11	7	35	8	6	10		13	11		
5. A car that will stop and pick you up if you signal it	13	1	4	4	4		3	6	4		6	7		
20B. Why do people use taxis?														
0. Doesn't know/no relevant response	10	7	3	0	0	-39	3	2	5		5	5		
1. Shows understanding of taxis as car/transportation, but not why people use them (to get places, they don't want to walk, etc.)	37	8	10	10	9		14	13	10		23	14		-19
6. Using a taxi is cheaper than buying or renting a car	7	1	3	3	0		3	1	3		6	1		-20
7. The people don't have a car to use	46	10	8	15	13		15	18	13		17	29		25

Table 1 (cont'd.)

20C. Do people have to pay to use taxis? . . . How does that work?

0. Doesn't know whether they have to pay or says that they do not	12	8	3	1	0	-39	4	4	4	5	7
1. Says yes but cannot elaborate or guesses dollar amounts without explanation	18	8	8	1	1	-37	7	8	3	6	12
2. The meter tells what the cost is	11	2	2	3	4		4	5	2	7	4
3. Cost is determined by the number of people or the number of stops made	6	1	1	2	2		2	1	3	3	3
4. Cost is determined by the time required	14	3	2	5	4		4	5	5	7	7
5. Cost is determined by how far you go	45	3	9	14	19	50	14	13	18	25	20
6. Cost is determined by the driver's boss	7	1	2	4	0		4	1	2	4	3
7. Shows clear understanding of taxis as local transportation that you pay for when you are not driving your own car	81	14	19	24	24	48	26	29	26	40	41

Table 1 (cont'd.)

21. How does a car work—what makes it go? . . . How does the engine make the car go?

0. Doesn't know/no relevant response	38	14	14	6	4	-39	12	15	11	16	22	
1. You use the key to turn on the car and make the engine go	15	5	2	2	6		5	5	5	8	7	
3. Pushing the pedal makes the engine go	17	2	3	4	8	25	5	6	6	10	7	
5. The engine makes the wheels turn	25	4	4	8	9	22	8	6	11	16	9	-17
6. The gas makes the engine go	27	3	6	8	10	24	9	7	11	15	12	
7. Other: wires from the engine make the car go, the battery gives power to the engine, piston motion in the engine is transferred to the wheels, etc.	15	1	3	6	5	22	6	2	7	9	6	

22. It's nice to have cars and trucks, but they create problems too. What are some problems that exist in places where most people drive cars or trucks?

0. Doesn't know/no relevant response	21	12	7	1	1	-46	7	9	5	12	9	

Table 1 (cont'd.)

1. Individuals' problems: blown tires, out of gas, etc. (code only if no codes in 2-8)	9	2	4	1	2		4	4	1		5	4
2. Difficult for people or animals to cross the road	8	0	1	2	5	28	2	3	3		3	5
3. Traffic jams, congestion, delays	27	3	4	11	9	31	12	6	9		12	15
4. Accidents	43	8	8	13	14	23	14	15	14		21	22
7. Noise	12	1	3	4	4		2	5	5		5	7
8. Air pollution, dust, gas/oil spills	18	1	2	9	6	34	3	4	11	29	8	10
23. What is a map?												
0. Doesn't know/no relevant response	6	4	2	0	0	-29	3	0	3		3	3
1. Something that tells you where places are/a representation of the state, nation, world	35	5	7	12	11	27	15	10	10		17	18
2. Something that helps you go where you want to go/tells you how to get from one place to another	80	19	20	21	20		24	29	27		41	39

Table 1 (cont'd.)

24. If people want to go to another country, can they just go, or do they have to get permission?

0. Doesn't know/no relevant response	13	2	7	3	1	NL	4	5	4	6	7	
1. Just go	39	8	12	10	9		13	15	11	17	22	
2. Need permission	44	14	5	11	14	NL	15	12	17	25	19	
3. Permission granted by government officials	17	2	2	7	6	25	6	4	7	12	5	-19

25. Why do we need stop lights on our streets? . . . What would happen if we didn't have stop lights?

0. Doesn't know/no relevant response	6	4	2	0	0	-29	4	0	2	4	2	
1. Cars would crash if we did not have them	33	7	8	7	11		11	11	11	16	17	
2. They control traffic, make sure that people stop for each other	46	7	11	16	12	27	14	15	17	24	22	
3. Other functions: they tell us if cars are coming the other way, keep people from traveling too fast, prevent traffic jams, etc.	8	3	2	1	2		3	3	2	3	5	
4. Without them there would be many more accidents	83	15	21	24	23	43	27	28	28	42	41	

Table 1 (cont'd.)

5. Focuses on pedestrians: they enable people to cross busy streets safely	10	6	1	0	3	NL	2	5	3	5	5

[1]Numbers in the frequencies columns show how many students in each group were coded for mentioning the ideas represented by the response category described at the left side of the table. Underlining indicates that the Chi-square for the underlined distribution was statistically significant at or below the .05 level. In these instances the phi coefficients (with decimal points omitted) are given in the phi columns (where significant linear trends were indicated) or else the letters "NL" appear to indicate that the relationship was nonlinear.

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